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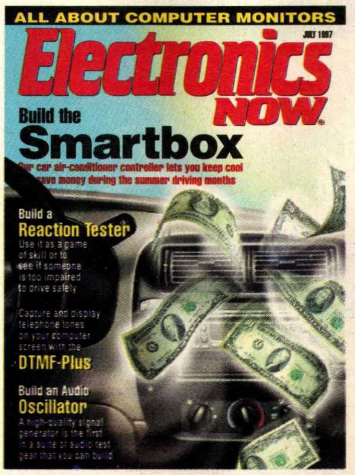
While driving this summer, have you hit the gas pedal only to find that the pick-up you expect is missing? Or have you noticed that your vehicle is not getting the gas mileage it normally does? The reason for that, in many cases, is your car's air conditioner. One solution would be to stop using it—hardly acceptable, especially on those scorching 90-degree days. Another, better, solution would be to build this month's cover project, the Smartbox. That unit synchronizes the air conditioner's operation to the engine, improving your car's performance when accelerating or climbing, and saving money in the process.
— Anthony J. Caristi



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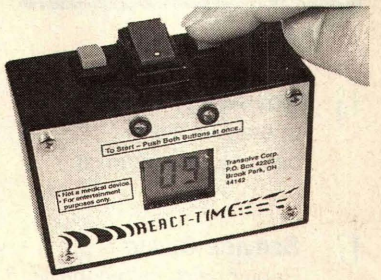

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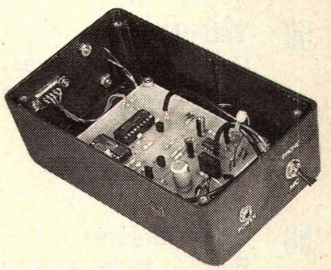

Capture, decode, and display telephone tones on any personal computer.
— Raymond C. Buck, III

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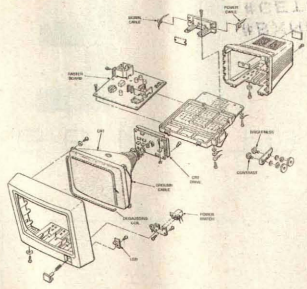

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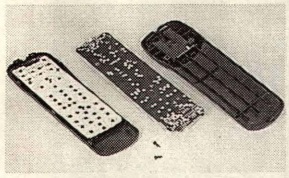

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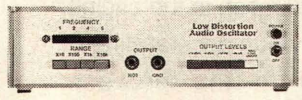

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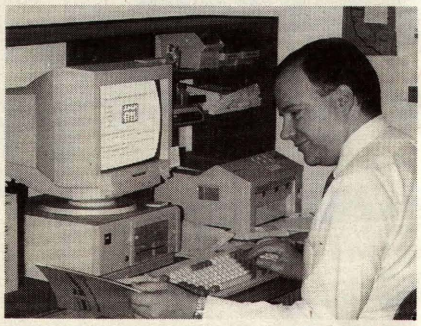

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EDITORIAL

The New Face of TV

On April 3, 1997, the nature and future of television was changed. On that date, the FCC adopted its long-anticipated rules for Digital TV (DTV). What's more, they set up an aggressive timetable for implementing the service, requiring broadcasters in the top ten markets to be on the air within two years, and the top 30 markets to be on the air within 2½ years. And broadcasters have further pledged to be on the air in some markets in 18 months. The FCC targeted 2006 as the year when all NTSC broadcasting will end forever.

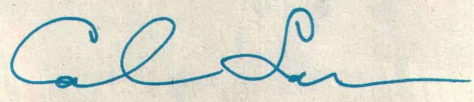
What will DTV mean to you? For one thing, it means you will need a new TV set, or an outboard converter box to use with your analog set. Aside from that, and in keeping with their recent history, the FCC will allow the marketplace to decide the face and shape of DTV. It could mean non-interlaced, High-Definition TV (HDTV), or a mix of digital products including interlaced standard-definition TV, subscription TV, interactive video, audio programming, data services, and more. The only requirements are that the broadcaster must maintain at least one free digital channel with the same or better picture quality and broadcast hours as their current analog channel, and that they fulfill their public-interest responsibilities.

Is everyone happy with this ruling? Hardly. For one thing, some consumer advocates and politicians are screaming murder over what they perceive to be a giveaway of valuable spectrum space. In truth, however, it is merely a short-term loan. Yes, broadcasters are being given a second channel that's equivalent in spectrum to the one they already have. However, they must give back their first channel when NTSC broadcasting ceases. Those channels can then be auctioned off. In the meantime, the availability of both analog and digital channels will greatly ease the transition process for both broadcasters and viewers.

Another less-than-happy group is the computer manufacturers. They were rebuffed in their push to make more computer-friendly, non-interlaced scanning part of the mandated standard. In fact, shortly after the FCC decision, Compaq, Microsoft, and Intel announced their own standard that, while compatible with the FCC guidelines, aims to eliminate interlaced scanning. Further, Microsoft has announced that the next generations of their Windows operating systems will include the technology to receive DTV broadcasts, but only using hardware that complies with the computer-industry standard.

The computer makers hope to have DTV-tuner cards ready for use with existing and new PCs by the fall of 1998. The consumer-electronics industry aims to have DTV sets in the stores in time for the 1998 Christmas shopping season.

Let the games begin.



Carl Laron
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WHAT'S NEWS

A REVIEW OF THE LATEST HAPPENINGS IN ELECTRONICS

Automated Inspection System

Researchers at the Georgia Institute of Technology have developed an automated on-line inspection system that uses advanced vision technology, neural networks, fuzzy logic, and wavelets to quickly identify defects in fabric. The system could cut inspection costs and reduce the amount of off-quality production, and could ultimately be the basis for an integrated electronic feedback system that would monitor and control quality processes throughout the manufacturing cycle. Developed with support from the National Textile Center University Research Consortium, the system has successfully operated on a loom at the Johnston Industries' Industrial Fabrics Group' Southern Phenix, Alabama plant since July 1996.

Fabric inspection is challenging and expensive for the textile industry, costing as much as $1 million a year at some manufacturing plants. That's because the industry uses many different types of yarns and weave patterns, quality standards can differ from one company to another, and existing systems rely on manual processes that are subject to human error. If not promptly detected and corrected, recurring problems in high-speed looms can damage thousands of yards of fabric. Although inspectors usually watch for problems during weaving, some defects are not identified until final inspection.

The Georgia Tech system automatically identifies defects as the fabric comes off the loom, so the manufacturer can immediately correct any problems. Dr. Lew Dorrity, a professor in Georgia Tech's School of Textile and Fiber Engineering, noted, "You would improve the quality of the manufacturing process, not just determine what quality exists in the finished products."

The system uses a special lighting arrangement and a set of high-speed cameras to scan fabric as it winds onto a take-up roll after weaving. A computer analyzes the information to identify abnormal patterns and determine whether they should be considered defects. The inspection system can also provide information to help companies pinpoint the factors that can cause defects, and it can provide a detailed record of weaving quality.

The system's reliability depends on cutting-edge software technology capable of rapidly processing information, learning from its mistakes, and mimicking human decision-making processes. "We have developed new and innovative software algorithms for the detection and classification of defects," explained Dr. George Vachtsevanos, a professor in Georgia Tech's School of Electrical and Computer Engineering. "We extract signatures from the images that are characteristic of the type of defect that might be present. We use a new wavelet/neural-network construct for this signature extraction, along with fuzzy logic decision support systems. The software integrates learning and optimization tools that avoid false alarms and improve the recognition accuracy."

The prototype Georgia Tech system, built from commercially available lighting, vision, and computer equipment, withstood heavy vibration, lint, and other severe operating conditions. Appalachian Electronic Instruments, a West Virginia maker of textile equipment, has licensed the technology and plans to turn the prototype into a commercial system that can be retrofitted to existing looms and installed in new machines.

Plans call for the use of new digital signal processing chips to provide additional speed. The system could be used for medical diagnostic evaluation, as well as for product inspection in the metals, food-processing, and pulp and paper industries. "We believe there are many generic features in these technologies that could be used in other industries that need this inspection capability," said Vachtsevanos. "There are possibilities far beyond the textile industry."

Wescon Headed for Silicon Valley

Wescon, the largest electronics trade event of its kind in the United States, and its semiconductor event, IC Expo, are moving from their traditional venue in San Francisco to the heart of Silicon Valley. The shows will take place November 4–6, 1997, at the San Jose McEnery and Santa Clara Convention Centers. This is the first time that any trade event has used both Silicon Valley convention centers simultaneously, and space at the San Jose McEnery site was sold out as of early March.

More than 80% of the attendees at previous Wescon shows in San Francisco commuted there from Silicon Valley. According to Wescon/97 show director, John Latimer, "Wescon's new Silicon Valley venues will greatly improve accessibility for the region's industry professionals. This new convenience, in conjunction with Wescon's new high-profile semiconductor event, IC Expo, positions Wescon to effectively meet the technology needs of an even greater number of attendees."

Exhibits on the two show floors will present a wide range of OEM products, including components, connectors, manufacturing/production/test equipment, packaging, power components, and design systems and software. IC Expo, located in the Santa Clara Convention Center, will have its own dedicated area where attendees will find advanced microelectronic devices, computer peripherals, board-level products, network equipment, and software tools. The Santa Clara Convention Center will also host most of the Applications Conference on Communications and Computer Technologies.

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LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Mod Box Modifications

In the article "Build the Mod Box" (**Electronics Now**, May 1997), which I co-authored with Jack Orman, several errors were introduced into our original hookup diagram when it was redrawn for publication as Fig. 2.

First, R17 erroneously appears twice on the circuit board. The resistor that lies between R15 and C7 is actually R7, not R17. The other R17, which lies on the right edge of the board, is correct. Next, capacitor C13 also erroneously appears twice on the circuit board. The capacitor that connects between pins 8 and 9 of IC1 is actually C3. The other C13, which appears in the upper left-hand corner, is correct.

Finally, the connections to J2 and J4 are in error, and volume potentiometer R14 is missing. Here's how to fix that. Pad "U" connects to the hot side of R14 only. Then, the wiper of R14 connects directly to J2, J4, and pad "W."

All of these corrections can be cross-referenced to the schematic, which is correct.

THOMAS HENRY

Determining the Velocity of Propagation

I found James E. Cicon's article, "Build the Cable Reflection Tester" (**Electronics Now**, December 1996) to be very informative, but I believe that more discussion of velocity of propagation (V_P) was needed. The article seems to imply that V_P is a function of cable type, which is untrue. V_P is determined by the dielectric material (the insulation surrounding the center conductor). The less dense, or closer to air, the dielectric is, the faster the V_P.

Older cables with solid polyethylene dielectric do indeed have a V_P of 66%. Newer cables have an air-entrained or foam poly dielectric. Early foams started in the 72% to 78% range. Current foam-dielectric, 75-ohm, CATV cables (RG59, RG6, and RG11) have a V_P of 82%–85%, depending on the generation and the manufacturer. The 50-, 52-, and 93-ohm series cables, with foam dielectric, should also exhibit similar V_Ps.

In a bench test with a Time Domain Reflectometer (TDR), using a length of RG59 foam-dielectric cable, the following was found: V_P 66% at 80 feet; 75% at 90 feet; 83% at 100 feet; 84% at 101 feet. As can be seen, it's important to be close on the velocity of propagation. Manufacturers should provide that information in their spec sheets, but often don't. If you have access to a physically measurable piece of the same type of cable that you need to test, you can calculate or experimentally determine the correct V_P.

Good luck with your cable testing. And thanks to Mr. Cicon for the article and this neat idea. I certainly plan to build a Cable Reflection Tester.

DON KISER
Salinas, CA

Designing the JamMix

In the April 1997 "Letters" column, Charles Hansen's letter on op-amp substitutions for my "JamMix" project (**Electronics Now**, October 1996) was absolutely on the mark. To further the discussion, our main reason for specifying the MC1458C device centered on the kit builder.

The MC1458C is a commonly available part; we found it at RadioShack. Its ESD characteristics should be better than op-amps with FET front ends, so novice kit builders would be less likely to damage the chip. And it is somewhat easier for a novice to troubleshoot than a quad package, but less assembly effort is required and there is a lower chance for error than when using single op-amps.

Our JamMix design journal contains notes showing that we looked closely at the Motorola MC1458S, which has 20 times better power bandwidth than the MC1458C. But the part was not thought to be universally available, and was therefore rejected. In responding to Mr. Hansen's letter, we did not have a data sheet handy for the TL072 Texas Instruments device, but our National Semiconductor Databook cross-referenced it to their LF353. The chip is described as a wide bandwidth dual JFET input op-amp. The NE5532 is a Philips high-speed op-amp. Those are both fine parts and indeed good performance upgrades for the 1458 series. We look forward to testing the TL072 and NE5532 chips, and hope to discern the sonic improvement that Mr. Hansen suggests.

When we designed JamMix, the first prototype was laid out on a multi-purpose board. We then developed the printed-circuit board with hand assembly in mind, and installed it in a case. We detected no ill effects from component selection or layout, so decoupling capacitors did not seem warranted. We were able to eliminate ten devices and the associated circuit board real estate, although we fully agree it is good design practice to decouple at the chip, as a rule.

WILLIAM C. HENDRY IV

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Sorry, Wrong Number

In my article "Build the Fuel Gauge" (**Electronics Now**, April 1997), I gave an incorrect telephone number for the parts supplier, Unicorn Electronics. The correct number is (607) 798-0260. I am sorry for any inconvenience that was caused.

JOHN PIVNICHNY EN

Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

Blast From The Past

Q *Around 1960-1962 your magazine, then called* ***Radio-Electronics****, had a column called "Noteworthy Circuits" in which a regenerative broadcast receiver was published. It worked surprisingly well, but I've lost track of it. Could you please print it again in "Q&A"? I'm sure others would be interested too. — R. G., Gig Harbor, WA*

A You have a good memory—the receiver was in our January 1962 issue, which credited it to the British magazine *Wireless World*. Figure 1 here shows the circuit, slightly reworked to use currently available parts. You can connect high-impedance headphones in place of R3.

A regenerative receiver is an oscillator that is biased so that it doesn't quite oscillate. It then operates as an amplifier with tremendous gain at the frequency to which it is tuned, and good rejection of all other frequencies. It also clips in such a way as to demodulate AM signals. This was an old-fashioned circuit even in 1962, but it produces a remarkably sensitive and selective radio with just one transistor or tube.

Using R4, you adjust the bias so that the gain is high but the receiver doesn't oscillate; that adjustment has to be tweaked every time you tune in a station, since the best setting depends on the strength of the incoming signal. When we breadboarded it, we heard AM stations 1000 miles away using just a 4-foot antenna; local stations came in loud and clear with no antenna.

You'll note that C3 is a 365-pF tuning capacitor. Those are not quite as easy to find as they used to be, but you can salvage one from an old, non-working radio or order one from Antique Electronic Supply, 6221 S. Maple Ave., Tempe, AZ 85283 (Tel: 602-820-5411). You could also substitute a 125-pF capacitor from a newer transistor radio, but you'll need to wind twice as many turns on L1.

And if you like simple radios, take a look at our December 1995 column, which featured an 8-component TRF radio built with the Ferranti ZN414 IC.

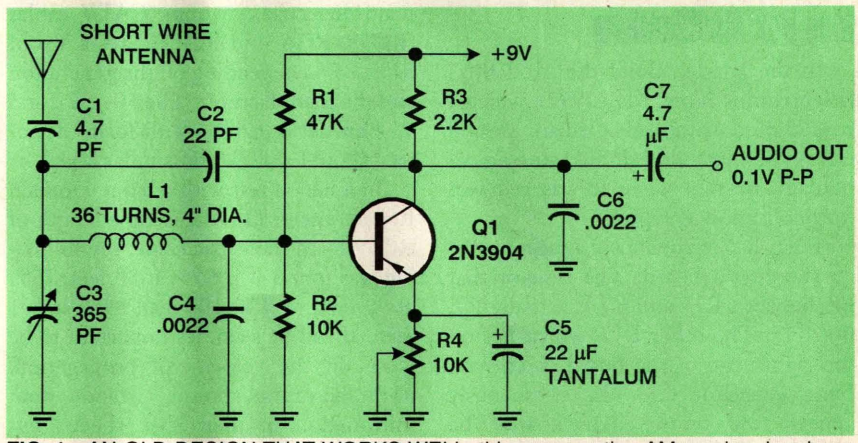

FIG. 1—AN OLD DESIGN THAT WORKS WELL, this regenerative AM receiver has been updated to use parts that are commonly available today.

Old Tube Needed

Q *I have a Philco portable radio that needs a new 3LF4, 3LE4, or 3V4 tube. I have not been able to find one. Is it possible to make changes in the wiring to use some type of transistor? — J. C. J., Denver, CO*

A You can get the 3LF4 and 3V4 from Antique Electronic Supply at the address given earlier in this column. It would be a pity to transistorize such an interesting and potentially valuable antique radio.

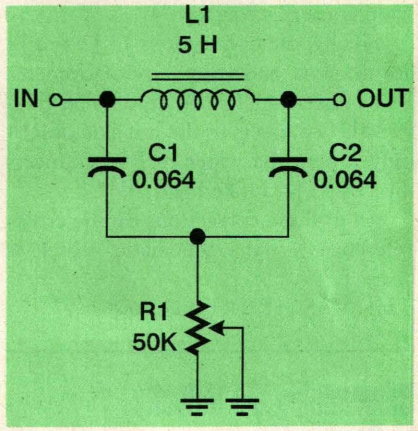

FIG. 2—AN OLD DESIGN THAT *DOES NOT* work well, coil L1 would be extremely hard to find these days, and the results produced by this circuit would not be worth the effort or the cost.

Audio Notch Filter

Q *I want to design a transistorized version of the distortion meter in the Gernsback book* ***High Fidelity****, published in the 1960s. I need to know the design specifics of the bridged-T network used as a null audio filter. Can you help? — J. S., Lakewood, NJ*

A To test an amplifier for distortion, you need a notch filter that eliminates one frequency from the signal. What you do, then, is apply a pure sinewave to the input, measure the output level, and then insert the notch filter to eliminate the original sinewave. What's left is total harmonic distortion plus noise.

The circuit that you describe uses a bridged-T filter as shown in Fig. 2, with a special, high-Q, 5-henry choke. That choke was hard to find 30 years ago, and is probably completely unavailable now. If you can find one, it might cost $50 or more. And even then, it won't give an

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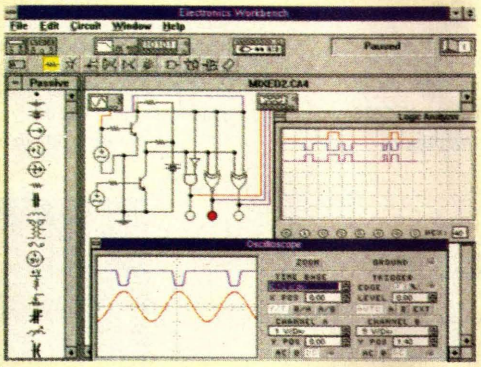

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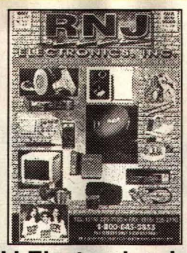

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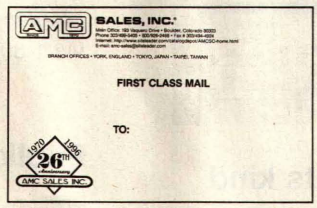

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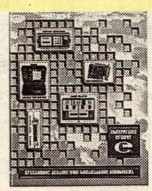

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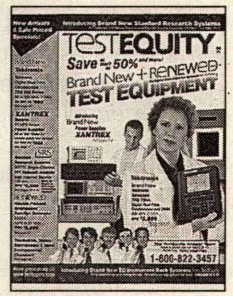

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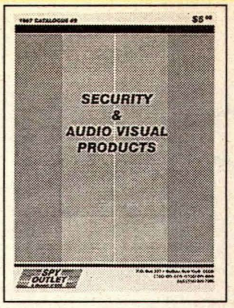

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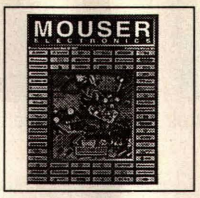

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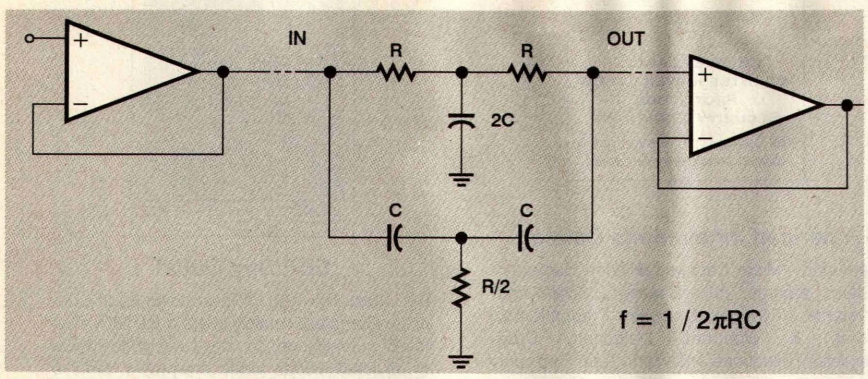

FIG. 3—THIS TWIN-T FILTER gives a better notch and is cheaper to build than the circuit in Fig. 2, though you should use precision components for best results.

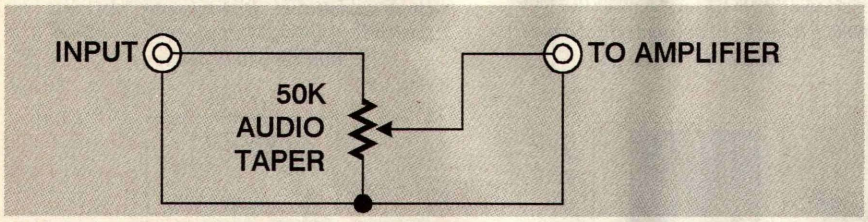

FIG. 4—HERE'S THE RIGHT WAY to hook up a volume control. For two channels, use a dual-gang potentiometer.

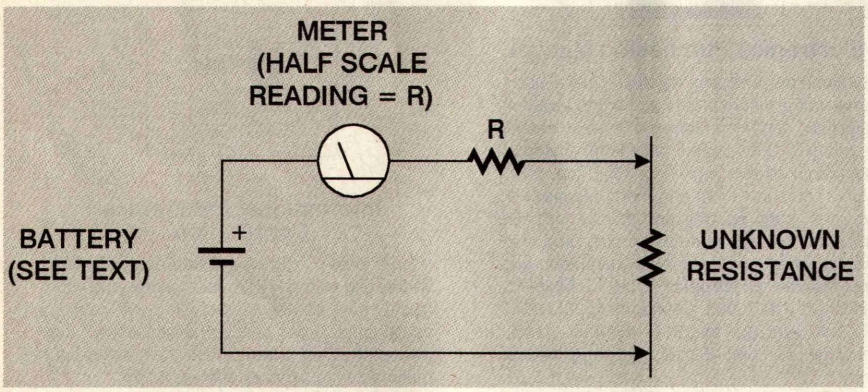

FIG. 5—HERE'S HOW TO BUILD AN OHMMETER. To compensate for battery aging, make R adjustable.

especially good notch, because any coil with an inductance of 5 henrys is going to have enough resistance to impair its performance.

Modern distortion analyzers use the twin-T network shown in Fig. 3. It gives a very sharp notch at a fixed frequency, and the components are cheap—just three resistors and three capacitors. Use 1% precision components and make one of them adjustable, so you can compensate for small errors in the values. For 1 kHz, R can be 1.6K, in which case R/2 is 800 ohms, C is 0.1 μF, and 2C is 0.2 μF. Better yet, instead of the 800-ohm resistor, use a 680-ohm resistor and a 200-ohm trimmer. For best performance, put the filter between two op-amp buffers as shown in the diagram.

A disadvantage of the twin-T network is that the frequency isn't variable. If you need multiple frequencies, build several networks and choose between them with a selector switch. For more about filters, see *The Art of Electronics*, by Paul Horowitz and Winfield Hill, Chapter 5 (more information on that book can be found in the box titled "How to Get Information on Electronics").

Finding Discontinued ICs

Q *I have a Heathkit digital multimeter that has served me well. The problem is finding replacement RTL logic chips to replace the original ones. Do you know of any vendor who deals in discontinued RTL ICs? — E. H. S., Clarendon Hills, IL*

A Discontinued ICs are the specialty of Rochester Electronics, 10 Malcolm Hoyt Dr., Newburyport, MA 01950 (Tel: 508-462-9332; email sales@rocelec.com). But it may be easier to find a used multimeter like yours at a hamfest or by advertising on rec.radio.swap, and salvage it for parts.

Add A Volume Control

Q *I recently acquired several Dynaco power amplifiers for almost nothing at a yard sale. How do I go about installing a volume control on these things? I've thought about putting a dual-ganged potentiometer in series with the input jacks—is this the proper way to do it? — J. R., Middletown, RI*

A Not quite; you'd probably get some hum, and the volume wouldn't go all the way down to zero because even a large series resistance can't block all of the signal. Instead, a volume control should be connected as a voltage divider in front of the amplifier input, as shown in Fig. 4. One channel is shown; you can use a dual-gang potentiometer and wire both channels the same way.

For best control at low volumes, use an audio-taper potentiometer. "Audio taper" means that when the potentiometer is set to half-scale, you'll get considerably less than half of the full signal; that's desirable because most audio systems operate far below maximum volume most of the time, and because the ear perceives loudness logarithmically.

Build An Ohmmeter

Q *The surplus dealers are offering beautiful 50-mA meters with ready-made ohms scales (full scale = zero ohms). What battery and resistance do I put with the meter in order to make an ohmmeter? — J. K., Clackamas, OR*

A Regardless of the meter characteristics, zero ohms will be full scale and infinity will be the other end of the scale. What you need to know is that the meter reads at half scale. That will tell you what resistance to put in series with it (see Fig. 5). Then you have to find a battery voltage that will make it read correctly. That's easy; you already know that it takes 50 microamperes to deflect it to full scale, so the battery voltage will be 0.00005 × R. It will probably turn out to be a standard battery voltage, per-

continued on page 16

EQUIPMENT REPORTS

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Most people with a home PC don't have the luxury of a scanner or copy machine. The usual reason for that is the perceived cost of those units relative to the amount of use they are likely to receive. Still, there are times when all of us wish we had a scanner on hand to quickly enter some printed text or a neat graphic for use in our own documents.

Well, owning a scanner has recently become more practical. That's because Interactive Efx Corporation has now introduced a desktop scanning solution for people with a desire to scan but more limited funds and desk space. The Personal Scanning Kit has a suggested retail price of only $199.99. It turns any PC into a small office by letting you scan and OCR (optical character recognition) documents, business cards, and images. Finally you can make copies at home, and even fax paper documents to others, instead of just being able to receive them with your fax/modem card. The Kit comes with all the software you need.

The Personal Scanner is black and white only, but that's a small sacrifice for finally being able to scan at all. The heart of the unit is a miniature auto-feed sheet scanner. It can handle anything up to 8.5-inches wide and practically as long as you like. All you need is a 486 or better PC with 8 MB of memory, a parallel port, and either Windows 3.1x or Win 95. The system comes with three programs: TypeReader Pro, Presto!Efx, and Presto! BizCard; those require 11, 6, and 4 MB of hard-disk space, respectively.

Installation

The personal scanner is tiny compared to most printers. It measures only 3¼ by 12⅛ by 3¼ inches, and makes itself at home in front of a printer. It connects to your computer's parallel port using an included cable, and has a pass-through connection for your printer. An AC adapter provides power. Sliding guides are used to adjust for paper width, and a paper stand attaches to the top of the scanner for paper to lean on. Paper moves into the top of the scanner and out the front.

The first part of the software installation is a TWAIN driver, which lets the scanner be recognized by any TWAIN-compliant software package and be operated by a standard set of controls. Next you install whichever of the three programs you are interested in. Let's discuss those next.

TypeReader Pro is the largest program of the three, and it's the one you use when you want to scan pages of text and save them as a document. We tested the program with single-spaced pages of 12-point Times New Roman text, and it averaged about two errors per page (not bad if you remember how unreliable scanners and OCR software used to be). The program activates the TWAIN interface, which controls the scanner's resolution up to 400 dpi, the mode (256-gray, B/W normal, B/W turbo, halftone), and scan size. You don't have to set the scan size; the software can wait to see what you scan.

Note that there are no controls on the scanner itself—not even power. The scanner turns on when paper is inserted. When you "press" the software's on-screen scan button, the sheet feeds through the scanner at a speed that varies with the resolution you've selected (a resolution of 200 to 300 dpi is fine for text OCR, while business cards and photos should be scanned at 400 dpi). It takes only a few seconds for each page to run through the scanner.

Once a page is scanned, it appears on the screen. You then select an area, usually a column of text, and have the software recognize the selected area. This, too, takes only seconds on a Pentium 200. You can feed in multiple pages, one at a time, and the software keeps track of the page order. After all the text is scanned and recognized, it can be saved as a text file or linked to a word-processing program.

Presto!Efx is intended for scanning and manipulating images. You can scan into a "tray" to save images as bitmaps, to a printer for copying pages, to a fax/modem, to a document, to an image editing program such as Corel, to a word-processing program, or to e-mail. The program and personal scanner did a beautiful job of scanning a color photo, albeit in black and white.

Presto!BizCard is geared toward scanning and saving the information on business cards. You run the card through the scanner, and the program does its best at sorting the information into fields for you. You can—and usually have to—edit the information in those fields. The program then lets you save and retrieve the information using various sort and search tools.

Of the three programs, this one gives the most disappointing results. But that is likely due to the fact that these days, business cards are often printed in wild colors, raised ink, metallic ink, and so on. However, in our test, it did recognize much of the information on a business card, and let us fix what it got

continued on page 18

Q & A

continued from page 12

haps 1.5 V. In fact, it might be just as quick to try various battery voltages until you find one that works.

Service Manual Needed

Q *Could you tell me where to obtain service literature and parts for a Thomson model 4120 video monitor? I have called Thomson Consumer Products, and they say they have no service manuals for this particular monitor. — B. K. B., Grand Rapids, MI*

A The service manual may not exist; unfortunately, many manufacturers treat computer monitors as disposable items, not intended to be repaired. But call Howard W. Sams & Co. at 1-800-428-7267 and see if they have anything in their files.

Clock Wanted

Q *Do you know of any available electronic clock (assembled, kit, or do-it-yourself project) that can pick up the time signal now placed in the retrace period by most local PBS TV stations?*

The primary purpose of this signal is to allow newer VCR machines to set their clocks automatically. It would seem that a stand-alone clock with the same ability would be a valuable addition to any household. — T. A. S., Maui, HI

A We don't, but it sounds like a great idea. If any of our readers can help, we'd love to hear from you.

What Makes It Stop?

Q *What makes a cassette tape player stop automatically at the end of the tape? How can this device be repaired? — B. B., Deming, NM*

A Usually, there's a small cam or lever that presses lightly on the tape to determine whether it's under tension. At the end of the cassette, the tape suddenly stretches tight, pushes on the cam, and actuates the auto-stop mechanism. If the cam is dirty, it will catch on the tape and actuate when it shouldn't. Try cleaning the cam and see if it helps.

HOW TO GET INFORMATION ABOUT ELECTRONICS

On the Internet: See our Web site at http://www.gernsback.com for information and files relating to our magazines (**Electronics Now** and **Popular Electronics**) and links to other useful sites.

To discuss electronics with your fellow enthusiasts, visit the newsgroups sci.electronics.repair, sci.electronics.components, sci.electronics.design, and rec.radio.amateur.homebrew. "For sale" messages are permitted only in rec.radio.swap and misc.industry.electronics.marketplace.

Many electronic component manufacturers have web pages; see the directory at http://www.hitex.com/chipdir/, or try addresses such as http://www.ti.com and http://www.motorola.com (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online.

Books: Several good introductory electronics books are available at RadioShack, including one on building power supplies.

An excellent general electronics textbook is *The Art of Electronics*, by Paul Horowitz and Winfield Hill, available from the publisher (Cambridge University Press, 1-800-872-7423) or on special order through any bookstore. Its 1125 pages are full of information on how to build working circuits, with a minimum of mathematics.

Also indispensable is *The ARRL Handbook for Radio Amateurs*, comprising 1000 pages of theory, radio circuits, and ready-to-build projects, available from the American Radio Relay League, Newington, CT 06111, and from ham-radio equipment dealers.

Copies of past articles: Copies of past articles in **Electronics Now** and **Popular Electronics** (post 1991 only) are available from our Claggk, Inc., Reprint Department, P.O Box 4099, Farmingdale, NY 11735; Tel: 516-293-3751.

Electronics Now and many other magazines are indexed in the *Reader's Guide to Periodical Literature*, available at your public library. Copies of articles in other magazines can be obtained through your public library's interlibrary loan service; expect to pay about 30 cents a page.

Service manuals: Manuals for radios, TVs, VCRs, audio equipment, and some computers are available from Howard W. Sams & Co., Indianapolis, IN 46214 (1-800-428-7267). The free Sams catalog also lists addresses of manufacturers and parts dealers. Even if an item isn't listed in the catalog, it pays to call Sams; they may have a schematic on file which they can copy for you.

Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502, and Manuals Plus, Box 637, Spanaway, WA 98387.

Replacement semiconductors: Replacement transistors, ICs, and other semiconductors, marketed by Philips ECG, NTE, and Thomson (SK), are available through most parts dealers (including RadioShack on special order). The ECG, NTE, and SK lines contain a few hundred parts that substitute for many thousands of others; a directory (supplied as a large book and on diskette) tells you which one to use. NTE numbers usually match ECG; SK numbers are different.

Remember that the "2S" in a Japanese type number is usually omitted; a transistor marked D945 is actually a 2SD945.

Hamfests (swap meets) and local organizations: These can be located by writing to the American Radio Relay League (Newington, CT 06111; http://www.arrl. org). A hamfest is an excellent place to pick up used test equipment, older parts, and other items at bargain prices, as well as to meet your fellow electronics enthusiasts both amateur and professional.

More About Printed Circuits

In January we described how to make printed circuit boards by laser-printing onto "PnP BLUE" plastic, then transferring the image to a copper-clad board that has been heated with an iron.

Klaus Fensterseifer wrote to say that he uses plain paper instead of PnP BLUE. We tried it and it works! The secret is not to try to peel the paper off after transferring the image. Instead, immerse the whole thing—paper and copper-clad board, held together by the toner image adhering to both—in water for a few minutes. The paper disintegrates and comes off leaving the toner sticking to the copper. In fact, the paper disintegrates even faster in etchant solution than in water.

continued on page 23

BY SAM GOLDWASSER

Repairing Remote Controls

AS WE SAID LAST TIME, MOST OF THE PROBLEMS ENCOUNTERED WITH REMOTE CONTROLS ARE THE RESULT OF THE ABUSE INFLICTED ON THEM BY KIDS, PETS AND EVEN OTHERWISE WELL-BEHAVED ADULTS. BUT, REGARDLESS OF WHY A remote fails to work, our job is to bring it back to operation. In this column I'm going to cover the most common types of problems and their solutions.

Before we go too far, however, there is one factor to keep in mind when it comes to remotes: all-purpose replacement remotes that cost less than $20 are available for most units. That means, unless you are doing the work for the pure enjoyment of it, it does not pay to expend a lot of time or money fixing a dead remote.

Getting Inside

Most of the problems with remote controls are physical in nature—dead batteries, gunk, bad connections, and such. Except for replacing bad batteries, some disassembly will be required. Manufacturers seem to be using more and more creative (read: obscure and difficult to open) methods of fastening the two halves of the remote shell together. There may be a small screw or two and/or the case may simply crack in half by gently prying with a knife or small screwdriver along the seam, or by sliding the two halves a fraction of an inch to unlock the catches. If the means of attachment is not obvious, look for screws inside the battery case, under a label on the rear, or hidden snap fasteners.

Dead Batteries

The solution for a dead-battery problem is obvious: replace them! However, if batteries tend to go dead quickly—the batteries in a remote typically last for years—then you may have a stuck button, some conductive grime under one of the buttons, or a defective IC. Then again, you might just be using cheap batteries; next time you change batteries in a remote, replace them with first-grade alkaline cells.

Corroded Battery Contacts

Corrosion caused by battery leakage is messy, but relatively easy to deal with. First dust out as much of the dried material as possible with a soft brush, and then remove the remainder with a damp, lint-free cloth or paper towel. Finish up by polishing the contacts with an ordinary pencil eraser, very fine sandpaper, or a nail file. If there is evidence that the leakage has made its way inside the case, you will need to open the remote and thoroughly clean the interior as well. Additional repairs might be needed if internal damage is evident.

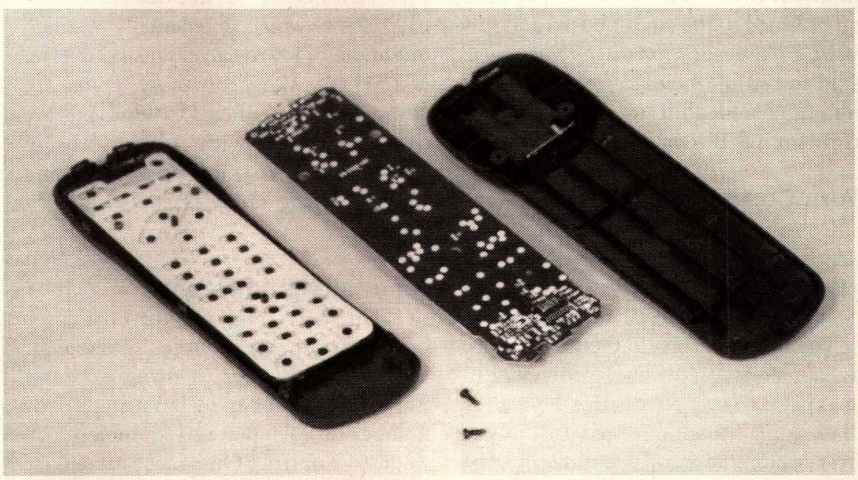
Broken or Intermittent Contacts

The place you most often find broken or intermittent contacts is between the battery connections and the circuit board. Carefully resolder and reinforce any suspect connections.

Another place to look for problem or cracked connections is at the solder joints on various component pins. Be particularly suspicious of the connections to components that are likely to be abused, such as selector switches. Reflow the solder on all suspect joints.

Broken Ceramic Resonator

The ceramic resonator, for those who



REGARDLESS OF THE CAUSE OF THE PROBLEM, servicing a remote means getting inside. If the means of fastening the two case halves is not obvious, look for screws inside the battery compartment or under a label on the rear.

do not already know, is usually a small blue or orange object that looks a little like a plastic or dipped capacitor. The circuit board marking is usually X1, CR1 or something similar. Though they are not that fragile, one could fail from shock when a remote is dropped. To test, assuming you have access to an oscilloscope, check for signals on one lead of the ceramic resonator. If all is well, you should see a signal at the carrier frequency when any button is pressed. A typical waveform should be at about 40 kHz with an amplitude of a few tenths of a volt.

Replacement resonators may be available from electronics distributors, or consider an organ transplant from a remote for equipment that has long since gone to the giant entertainment center in the sky. Just make certain your replacement is the same frequency as the original.

Dirt, Spills, and Gunk

Any of those could cause circuit problems that prevent keys from operating reliably or physical problems that result in keys that are just plain stuck or sticky. Disassemble the remote completely (and carefully), and wash both sides of the rubber membrane keypad, circuit board, and plastic case with water (and mild detergent, if necessary, to remove sugar-based grime) and then isopropyl alcohol. Dry thoroughly, reassemble, and see if the problem, is solved.

Worn or Corroded PC Pads

If you run into problems with the PC-board foil traces or pads, conductive epoxy or other similar conductive paint or ink can be used to make the repair. Alternatively, a piece of thin copper foil can be glued to the circuit board and soldered to the appropriate circuit trace. Gold foil would be even better, since it will not corrode, but might be just a tad costly for a $10 remote!

Worn Conductive Material

Compare the bottoms of frequently-used keys with those that are rarely pushed. If you can see the rubber through the conductive material after cleaning, the pad is likely worn to the point of being non-functional. That problem can be repaired with conductive epoxy, or other similar conductive paint of ink. A sliver of aluminum foil can sometimes be glued to the rubber surface. 3M makes EMI/RFI shielding tape, type 1181, that should work very well in this kind of repair.

Cracked Circuit Board

Since the circuit boards found in most remotes are quite simple, single sided, and have relatively wide traces, a cracked one generally is easy to repair. Use epoxy cement or an adhesive like Duco Cement or windshield sealer to repair and reinforce the circuit board. Scrape off any insulating coating and jumper the breaks with fine wire and solder. Don't just bridge the gaps with solder; if you do, cracks and future problems are a certainty.

Bad IR LED

Test the LEDs with an external power supply (using a current-limiting resistor) and an IR detector like the one discussed last month. If you don't have (or want to build) an IR detector, you could substitute a visible-light LED and see if it lights when keys are pressed. If the LEDs appear not to work, use an oscilloscope or DMM to monitor the voltage across them to make sure they are getting a signal. If you use an oscilloscope to monitor the drive to the LEDs, you should see the pulse-code-modulated carrier. If you determine that the IR LEDs are faulty, you can replace them with any readily available high-intensity IR LEDs.

Bad IC

Generally there is one single IC in each remote. If it is a custom chip, throw the remote away! Check each pin on the IC with an oscilloscope to determine if it is really dead. A note from one of my followers, Duane P. Mantick suggests, "An awful lot of IR remotes use ICs from the same or similar series. A common series comes from NEC and is the uPD1986C which, incidentally is called out in the NTE replacements book as an NTE1758. Many of those chips are cheap, not too difficult to find, and are in easy-to-work-with 14- or 16-pin packages. Unless you have no soldering or desoldering skills, replacement isn't difficult.

Alternatives to Repair

There are a large number of preprogrammed universal remotes available for use as replacements, starting at about $10. They are set up by inputting a code number for each piece of equipment you want to control. One piece of advice with these: Don't lose the instruction manual or you will not know what the codes are or how to enter them if the remote happens to lose its memory or the batteries go dead. Also be sure to write the settings in ink on a label on the back of the unit and slip the same information on a small piece of paper inside the battery compartment.

You should note that there are a couple of drawbacks to these as well. One is that you won't necessarily be able to control everything that you could with the original remote, especially if your unit and remote was loaded with bells and whistles. Another is that if the gear you want to control is a little more obscure, you should make sure that the universal remote can handle it.

If either of those points presents a problem, universal learning remotes are available at a higher cost, about $25 and up. The better ones are capable of memorizing all of the actual signals sent by your original remotes by viewing the IR transmission directly. Of course your existing remotes must be working properly. The advantage of a learning remote is that it can be taught to perform setup, adjustment, and programming functions as well as those for normal operation.

A third alternative is to get an exact replacement from the original manufacturer. In many cases, however, that will cost quite a bit more—the average price for a replacement is a rather inflated $40.

That's it for this month. Hope to see you again next issue with more basic servicing information to help you keep your home electronics running smoothly. EN

EQUIPMENT REPORTS

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wrong. If you are entering business-card information anyway, this software at least gives you a head start on the task.

All in all, the Personal Scanning Kit is a very versatile item to have in a small office. It lets you do those little things you often want to do with a personal computer, but usually can't. If you make money entering text, you could save time and effort with it. And if you dabble in desktop publishing, your new documents will sparkle with photos, custom logos, and more. It is also an easy and inexpensive way to add the ability to handle hard copy to your existing Fax modem.

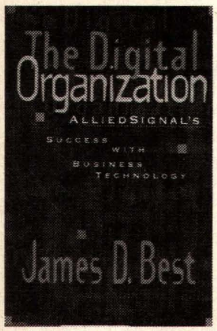
For more information on the Personal Scanning Kit, contact Interactive Efx Corporation directly (1265 Birchwood Drive, Sunnyvale, CA 94089; Internet: www.interactive-efx.com), or circle 15 on the Free Information Card. EN

NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

The Digital Organization: AlliedSignal's Success with Business Technology

by James D. Best
John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10158-0012
Tel: 1-800-225-5945
Web: http://www.wiley.com
$29.95



CIRCLE 338 ON FREE INFORMATION CARD

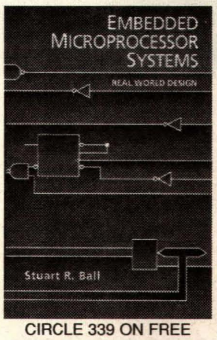
A "digital organization" is a company that has integrated information technology into its infrastructure. This book shows you how to develop and implement a business strategy that will transform your company into a successful digital organization.

As head of AlliedSignal's Computing and Network operations, the author was responsible for melding the three companies—Bendix, Garrett, and Allied Chemical—that made up Allied's foundation into one. His task was to create a stronger communications and networking system between three disparate business sectors. By adapting available technology to the needs and objectives of his company, the author helped develop a solid strategy that, in effect, combined Allied's parts and made them into a unified whole—and one of the most successful digital organizations around.

The book delivers the blueprint you need to make information technology initiatives a vital and effective part of your company's infrastructure. With clear explanations and straightforward advice, it reveals the details of designing a game plan that integrates your people, processes, and computer systems. Real-world examples from a variety of high-tech companies illustrate how to incorporate computer culture into your business and effectively manage and align computer operations with the rest of your organization. An easy-to-follow, seven-step program offers insights on building and managing an information technology department, identifying technologies that will support your company's overall purpose, and funding information technology initiatives.

Embedded Microprocessor Systems: Real World Design

by Stuart R. Ball
Butterworth-Heinemann
313 Washington Street
Newton, MA 02158-1626
Tel: 617-928-2500
Fax: 617-928-2620
Web: http://www.bh.com/el
$29.95



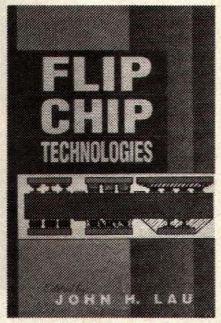
CIRCLE 339 ON FREE INFORMATION CARD

This book presents an introduction to the design of embedded microprocessor systems from concept through debugging. Unlike many microprocessor books, this one is not limited to any specific processor family. Instead, it describes interfaces and operations of several families, with an emphasis on cost and design trade-offs. Two complete embedded systems are used throughout to illustrate specific concepts.

The text includes many practical examples and tips, and points out potential pitfalls—which can help prevent time-consuming and expensive mistakes. Particularly important is the chapter on interrupts, which includes detailed descriptions of possible problems and warnings on what to avoid.

Flip Chip Technologies

edited by John H. Lau
McGraw-Hill, Inc,
11 West 19th Street
New York, NY 10011
Tel: 1-800-822-8158
$79



CIRCLE 340 ON FREE INFORMATION CARD

The use of flip chip technologies can help designers keep pace with two trends in the electronics industry—making products smaller, thinner, shorter, and faster, while at the same time making them more friendly, functional, powerful, reliable, and less expensive. This one-stop guide to flip chip technologies is aimed at professionals who are active in flip chip and multichip module (MCM) research and development; those who want to master flip chip and MCM problem-solving methods; and those who must choose a high-performance and cost-effective design and high-yield manufacturing process for their interconnect systems. It meets the reference needs of design, material, process, equipment, manufacturing, quality, and system engineers, as well as technical managers working in electronic packaging and interconnection.

Contributions from a wide array of experts cover the most advanced research and solutions in the flip chip technologies today. The book includes discussions of solder-bumped, conductive-polymer, anisotropic-conductive, wired, and TAB flip chip technologies, among others.

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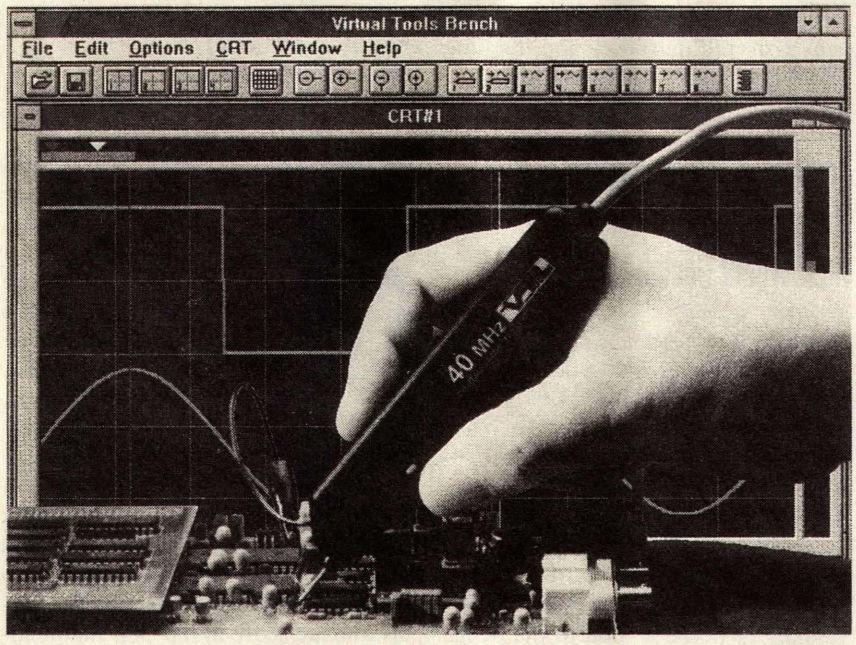
NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Digital Sampling Oscilloscopes

Two digital sampling oscilloscopes (DSOs) from Virtual Tools, Inc. have maximum sampling rates of 20 MHz and 40 MHz with 8-bit resolution. Both DSOs feature 24 sampling rates, seven sampling depths with a maximum of 32K samples, and six input voltage ranges. The internal trigger-level adjustment spans the full 8-bit range with positive or negative slope selection. Alternate trigger sources include external and a manual trigger located on the probe. The user can also choose data collection after the trigger, before the trigger, or half before and half after the trigger. The DSOs are packaged in 5- by ½-inch probe-style cases with five-foot connection cords.



CIRCLE 20 ON FREE INFORMATION CARD

The digital sampling oscilloscopes connect to the host IBM or compatible PC via a standard parallel port with one of Virtual Tools' interface adapters. The adapters, which are available with either two or eight channels, allow interaction between the connected instruments. A rechargeable battery option is available for the eight-channel adapter.

The Virtual Tools Bench software runs in Windows 3.1 or higher and can run on PCs or laptops with 4 megabytes of RAM. The program is structured with separate data-display and instrument-control surfaces. That approach allows appropriate instrument-control surfaces to be called up as needed while otherwise leaving maximum screen space available for data display. The type of instrument connected to each channel is detected by the software, and a default control surface is automatically installed. The user can select alternate control surfaces for each channel. Up to four data-display windows are available, and data from each of the instruments can be selected for display in each window independently, which allows multiple views of the data. Collected data can be saved for later display or export to other programs.

The 20-MHz DSO costs $199, the 40-MHz DSO costs $249, the two-channel interface adapter costs $39, and the eight-channel adapter costs $79 ($99 with the battery-power option). The software is included. Instrument bundles are available at reduced prices.

VIRTUAL TOOLS, INC.
725 Southgate Court
Oceanside, CA 92057
Tel: 619-940-0259
Fax: 619-940-1427
E-mail: vtools@virtualtools.com
Web: http://www.virtualtools.com

Industrial ScopeMeter

The Fluke ScopeMeter 123 combines the three most frequently used service tools—oscilloscope, multimeter, and recorder—in a small, battery-powered tool that offers all the measurement functionality needed to do an effective service job. The multifunction, industrial handheld instrument provides fast answers for troubleshooting machinery, instrumentation, and control and power systems. The ScopeMeter 123's small size and its "connect and view" simplicity provide engineers and technicians with one versatile tool that covers just about all front-line troubleshooting tasks.

When the ScopeMeter 123 test tool is used to check several test points, the user will always get a stable waveform on the display. No matter what the signal looks like, all signal detail will be revealed, including spikes, noise, and even the complex waveforms used in motor drives. Proprietary circuitry continuously analyzes input signals, and the microprocessor analyzes that information to control the instrument settings. With hands-free connect-and-view operation, no button pushing is needed to display a stable and reliable signal, even when a new test point is probed.

The ScopeMeter 123's newly developed shielded test lead not only takes multiple meter readings, capacitance and resistance measurements, and continuity

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BY JEFF HOLTZMAN

How to Become a Better Coder

MY APRIL COLUMN ("HOW NOT TO BE A BAD CODER") RESONATED WITH LOTS OF READERS, MANY OF WHOM HAD WAR STORIES OF THEIR OWN TO SHARE. SEVERAL PEOPLE, HOWEVER, ASKED RELATED QUESTIONS, WHICH IN ESSENCE BOILED down to this: "I know my coding is not as good as it could be. How can I make it better?"

As I began thinking about it, the question appeared more and more intriguing. Much of my initial thinking centered around the technical aspects of programming. (Learn CPU architecture, memory architecture, object-oriented programming, . . . etc., etc., etc., *ad nauseum*.)

Later I realized that all the technical things I had been considering were really limited aspects of the overall answer. I also realized that there is not a single one-size-fits-all answer.

If you assume that programming ability follows a normal distribution curve, we can simply lop off both ends. Those at the top don't need any help, and those at the bottom won't benefit no matter what we do. So our real audience is the 80% in the middle; those individuals exhibit a broad range of programming skills, a broad range of other skills, broad knowledge of other domains (both technical and practical), and a broad range of personality types. In most real-world situations, the other issues will be as important, if not more so, than raw technical ability.

That's not to say that a narrowly focused specialist with the personality of a dead moose can't succeed. However, well-rounded individuals will always be more valuable both to themselves and to the businesses that hire them.

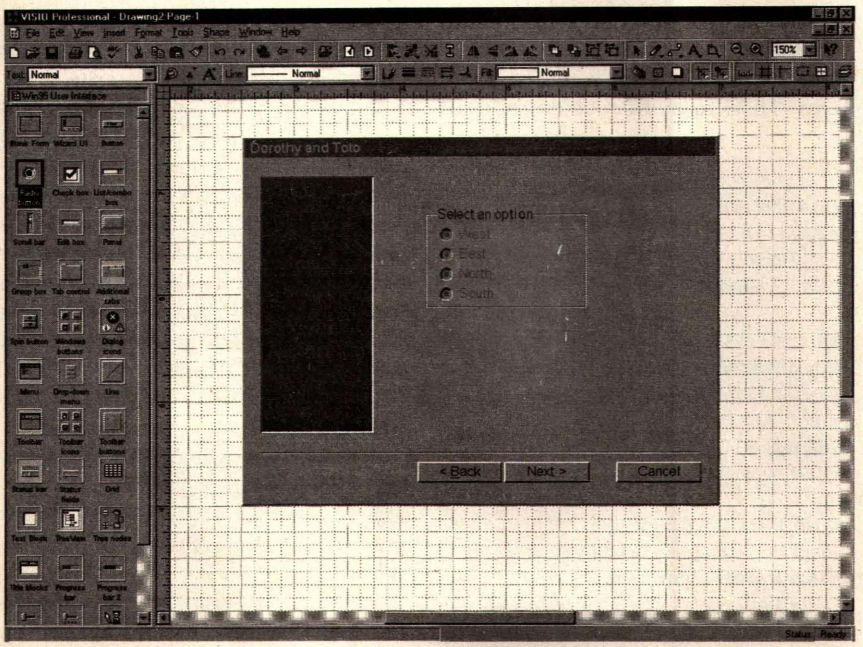


FIG. 1—IS THIS A NEW WIZARD FOR THE INHABITANTS OF OZ? No, it's a Visio user-interface design template. Visio is the drawing program for people who work with ideas.

Programming is Not Just Programming

The reason for that last statement is that in most real-world situations, programming is not just programming. It is not a "pure" activity, without constraint, like proving theorems. Rather, it is an engineering activity that almost always involves complex trade-offs among cost, schedule, product quality, design purity, resource usage, speed, integration, and other factors.

One key element of becoming a better programmer is to be able to recognize, evaluate, and act on each element of the trade-off matrix. That type of knowledge can only be gained through experience. But if you just rush through your programming experience like a freight train through the countryside, you won't learn anything. Rather, you will be wasting your time. To avoid wasting time, I suggest the following:

After each "increment" of programming experience, which could be as large as an entire project or as small as a single line of code, ask yourself what went right, what went wrong, and what you can do to maximize the former and minimize the latter. Then act on the answers that you come up with.

If you can retain a receptive state of

mind, you might find that you develop the ability to "receive messages" in real-time about your work process. (Yes, you are both transmitter and receiver.)

Cost and budget pressures serve to lower the signal-to-noise ratio of those messages. Cost and budget also tend to increase the stress factor, which gives a positive feedback loop. In other words, as stress increases, receptivity decreases, which lowers performance, which increases stress, and so on.

You'll find that most of what you learn has nothing to with technical knowledge. The most valuable items concern the setting or context in which you do your work, including the people you work with and for, the types of problems you work on, time and financial constraints, and how you approach the problems you encounter.

Of course, without some modicum of technical ability, all that other stuff is irrelevant. If you're not a technical genius to begin with, you're not going to become one. But whatever your skill level, you can become more effective, more efficient, more valuable, more highly paid, and more satisfied.

Hints

To help you along in the process of becoming a better coder, here is a selection of thoughts focused on how to improve competence, technical and otherwise:

Don't reinvent the wheel. Probably 99% of all application-related computing problems have already been solved. Be aware of prior solutions, so you can either reuse or improve them. Being aware of prior solutions also helps you to not embarrass yourself with an incorrect or inefficient solution.

View problems as systems. No man is an island. Nothing exists in isolation. Everything can potentially affect everything else, particularly in software. Get in the habit of seeing systems as collections of interactive components whose collective behavior defines the nature of the system.

Read a lot. Stay on top of what the current issues, trends, and even fads are in your area of interest. Know what solutions already exist, and what their strengths are. If you have any interest in developing your own products, look for gaps or products with major limitations.

Write a lot. Practice doesn't make you perfect, but it keeps you mentally limber, and it puts you in the frame of mind to receive process-improvement messages.

Continually reinvestigate fundamentals. Cramming for the CS-101 final may get you through college, but it won't make you a better programmer. While I'll be the first to admit that it's hard, occasional reviews of algorithms, data structures, language fundamentals, and the like will improve your problem-solving ability.

Keep priorities straight. Everyone who has worked in a technical position in industry for longer than five minutes has gotten sidetracked into technical debate about (and even development of) subsidiary features that do not have a major impact on the overall product. Know what your goals are, even if your manager doesn't. Always keep those goals in mind, and you will succeed.

Only optimize where it's worth it. A corollary of the preceding is that not all parts of any given project are equally performance sensitive. Instrument your code to detect bottlenecks, and focus there. Any time you're optimizing without a specific objective in mind, you're squandering resources.

Technically interesting does not equal value to the project. Another corollary is that all components of a project must work, not just the "interesting" ones. Don't fool yourself about what needs to be done. Always keep the forest in mind while working on individual trees.

Strive for simplicity; be suspicious of complexity. Don't be simple-minded, but seek to recognize (in the problem domain) and create (in your code) patterns. That's really what object-oriented programming is all about: Creation of a hierarchy of patterns, with the hierarchical structure itself informing and enforcing relations among the elements of the hierarchy. If you can't explain something, it's not simple. Nor do you understand it well enough.

Stay in touch with the community. Know what people in your physical locale and mental domain are thinking and feeling. If you find yourself thinking and feeling vastly different things, you may want to change jobs.

Work with a mentor. Lose your ego. Get your code reviewed by experts. Learn from what they say, and don't take it personally. Try to institute code reviews and design walk-throughs on the job. Younger members will learn, and senior members (and management) can stop little problems from becoming big ones.

Practice "spiral learning." Learn everything you can about components. Get a broad background, but also focus in detail on several complex, specific examples. Then learn everything you can about a single small system. Then tackle a larger system. Then another. Then another. With maybe a dozen small systems under your belt, you'll be ready to attack system integration. (Here learn does not mean study. It means build and make work. If you fail occasionally, so be it; you'll still learn.) All that will keep you busy for ten to twenty years; then you'll be ready to lead and advise others.

RESOURCES

Unauthorized Windows 95
by Andrew Schulman ($39.99)
IDG Books, 1994
ISBN: 1-56884-305-4

VToolsD ($495)
Vireo Software, Inc.
21 Half Moon Hill
Acton, MA 01720
Tel: 508 264-9200
Internet: www.vireo.com.

Visio Technical 4.5 ($299)
Visio Professional 4.5 ($349)
Visio Corporation
520 Pike Street
Suite 1800
Seattle, WA 98101
Tel: 800 248-4746, 206 521-4500
Internet: www.visio.com.

Win95 Port I/O Revisited

Last month I presented a technique for directly accessing I/O ports under Windows 95. In the back of my mind was a rule that I probably should have made explicit, to wit: The proper way to access ports in Win95 is via a virtual device driver, or VxD. The subject of VxDs is complex. A good source for understanding VxD architecture is Andrew Schulman's *Unauthorized Windows 95*. For coding VxDs, you'll almost certainly want to get a copy of Vireo's VToolsD.

Visio 4.5

Visio is the drawing program for anyone who needs to represent ideas pictorially. I was enthusiastic about the program when it came out in 1992; I remain as enthusiastic as ever.

In a nutshell, Visio provides a stencil-based drag-and-drop drawing system. Stencils hold shapes, which range from circles and rectangles to transistors and

continued on page 60

Q & A

continued from page 16

After etching, the toner is hard to remove from the copper. Most solvents don't work; Rick Detlefseg wrote to tell us that lacquer thinner does. Lacquer thinner is toxic, flammable, and smelly; so it should only be used outdoors.

Frequency Display Found

In the March issue, reader P. W. asked about an add-on digital frequency display for a shortwave receiver. We've found one—a kit made by Almost All Digital Electronics, 1412 Elm St. S.E., Auburn, WA 98092. It works with any receiver IF up to 32 MHz and sells for $49.95. Full information is available on the Internet at http://www.aade.com.

More CCD Resources

Regarding J.G.'s question on CCD devices in the February installment of this column, thanks to Derek Koonce of Supertex, Inc., we have the following additional sources of information:

- Dalsa, Inc., 550 Parkside Dr., Waterloo, Ontario, Canada N2L 5V4 (*CCD Image Sensors* data book and application notes);
- EG&G Reticon, 245 Potrero Ave., Sunnyvale, CA 94086 (*Image Sensing Products* data book);
- Fairchild Weston-Schlumberger, 1801 McCarthy Blvd., Milpitas, CA 95035 (*CCD Solid State Imaging* data book);
- Thompson Components, 550 Mt. Pleasant Ave., Dover, NJ 07801 (book titled *The CCD Image Sensor*, a very good reference);
- Photometrics, 2010 N. Forbes Blvd., Tucson, AZ 85745 (*Charge-Coupled Devices for Quantitative Electronic Imaging*).

Writing to Q&A

As always, we welcome your questions; write to: Q &A, **Electronics Now**, 500 Bi-County Blvd. Farmingdale, NY 11735. The most interesting ones are answered in print. Due to the volume of mail, we regret that we cannot give personal replies. EN

Wavetek. The Way Value Is Measured.

For the best values in digital multimeters everyone is turning to the Wavetek XT Series. Each of these full-function DMMs measures voltage, current, resistance, and also a set of additional electrical or electronic properties you work with every day. Inductance. Capacitance. Frequency. Temperature. There is an XT Series DMM right for you.

With oversized character displays, these DMMs are as easy to read as they are to use. All have fully-fused current inputs and input warning beepers to protect you and the meter. Each comes with safety test leads and are approved to IEC1010-1 safety standards.

Our commitment to reliability and high quality is backed by the industry's only "No Hassle" warranty program. If your XT Series meter requires warranty service, your local dealer replaces it immediately. Call today for full details and the names of your local Wavetek distributors. You'll find that when it comes to Wavetek performance and price, nothing else measures up.

27XT *A unique combination of DMM and component checking in a single meter:*
- *Inductance*
- *Capacitance*
- *Logic*
- *Frequency*

23XT *Electronic and electrical test functions for general duty and HVAC/R.*
- *VAC Safety Tester™*
- *Temperature*
- *Transistor*
- *Logic*

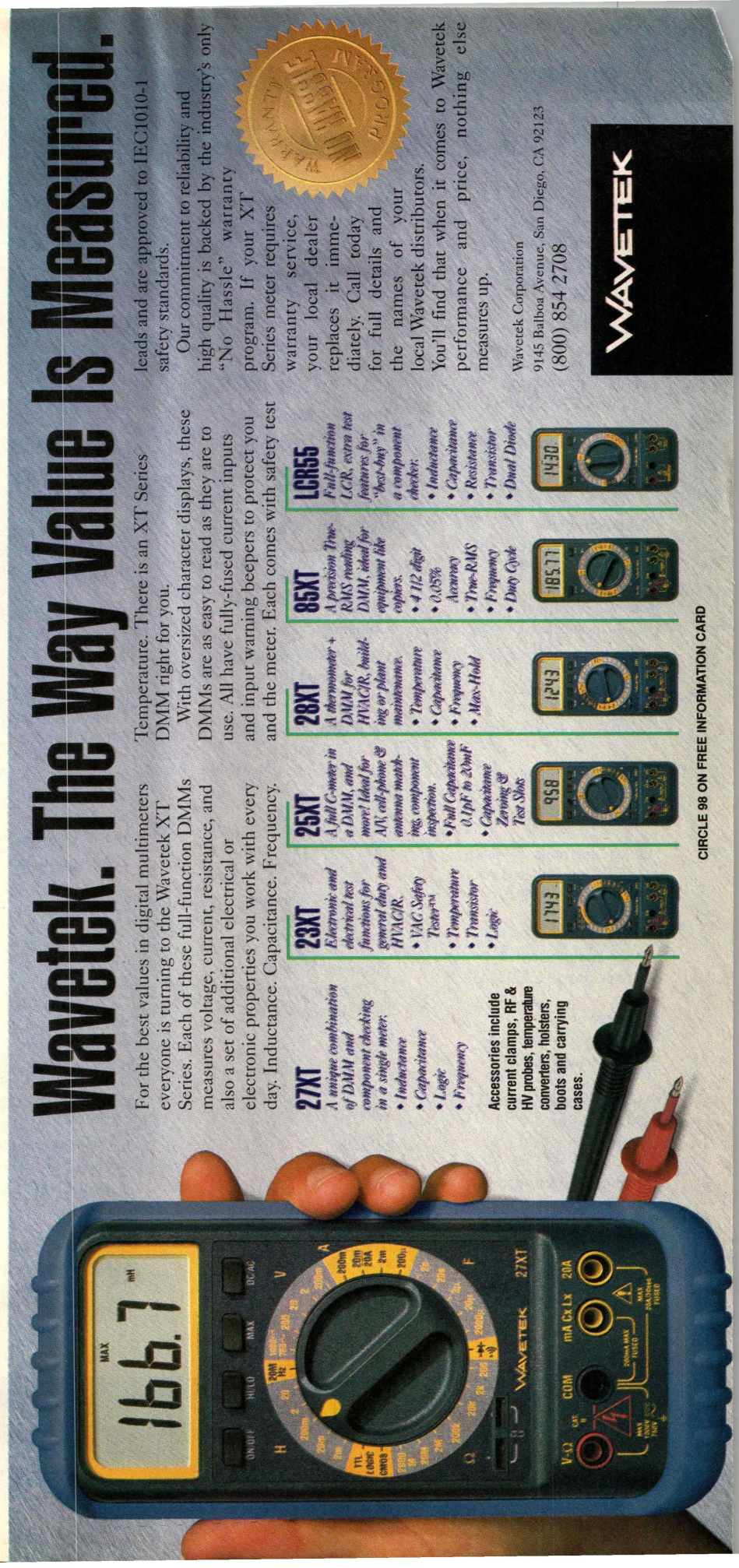
25XT *A full C-meter in a DMM, and more! Ideal for A/V, cell-phone & antenna matchings, component inspection.*
- *Full Capacitance 0.1pF to 20mF*
- *Capacitance Zeroing & Test Slots*

28XT *A thermometer + DMM for HVAC/R, building or plant maintenance.*
- *Temperature*
- *Capacitance*
- *Frequency*
- *Max-Hold*

85XT *A precision True-RMS reading DMM, ideal for equipment like copiers.*
- *4 1/2 digit*
- *0.05% Accuracy*
- *True-RMS*
- *Frequency*
- *Duty Cycle*

LCR55 *Full-function LCR, extra test features for "best-buy" in a component checker.*
- *Inductance*
- *Capacitance*
- *Resistance*
- *Transistor*
- *Dual Diode*

Accessories include current clamps, RF & HV probes, temperature converters, holsters, boots and carrying cases.



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9145 Balboa Avenue, San Diego, CA 92123
(800) 854 2708

WAVETEK

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RETAILERS THAT SELL OUR MAGAZINE MONTHLY

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Ford Electronics
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Buena Park, CA 90621

All Electronics
14928 Oxnard Street
Van Nuys, CA 91411

Gateway Electronics of CA
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San Diego, CA 92123

Mac's Electronics
191 South "E" Street
San Bernardino, CA 92401

Electronics Warehouse
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Riverside, CA 92501

Orvac Electronics
1645 E Orangethorpe Ave.
Fullerton, CA 92631

Sav-On Electronics
13225 Harbor Blvd.
Garden Grove, CA 92643

JK Electronics
6395 Westminster Blvd.
Westminster, CA 92683

Marvac Dow Electronics
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Oxnard, CA 93030

Kandarian Electronics
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Bakersfield, CA 93301

Whitcomm Electronics
105 W. Dakota #106
Clovif, CA 93612

Marvac Dow Electronics
265-B Reservation Road
Marina, CA 93933

Minuteman Electronics
37111 Post St., Suite 1
Fremont, CA 94536

HCS Electronics
6819 S. Redwood Drive
Cotati, CA 94931

Halted Specialties Co.
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Santa Clara, CA 95051

Metro Electronics
1831 J Street
Sacramento, CA 95814

HSC Electronics
4837 Amber Lane
Sacramento, CA 95841

Colorado

Gateway Electronics of CO
2525 Federal Blvd.
Denver, CO 80211

Centennial Electronics
2324 E. Bijou
Colorado Sps., CO 80909

Connecticut

Signal Electronics Supply
589 New Park Avenue
W. Hartford, CT 06110

Cables & Connectors
2198 Berlin Turnpike
Newington, CT 06111

Electronic Service Prod.
437 Washington Avenue
North Haven, CT 06473

Georgia

Norman's Electronics, Inc.
3653 Clairmont Road
Chamblee, GA 30341

Illinois

Tri State Elex
200 W. Northwest Hwy.
Mt. Prospect, IL 60056

Maryland

Mark Elec. Supply Inc.
5015 Herzel Place
Beltsville, MD 20705

Amateur Radio Center
1117 West 36th Street
Baltimore, MD 21211

Massachusetts

U-Do-It Electronics
40 Franklin Street
Needham, MA 02194

Michigan

Purchase Radio Supply
327 East Hoover Avenue
Ann Arbor, MI 48104

Norwest Electronics
33760 Plymouth Road
Livonia, MI 48150

The Elec. Connection
37387 Ford Road
Westland, MI 48185

Elec. Parts Specialists
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Flint, MI 48506

Minnesota

Acme Electronics
224 Washington Avenue N.
Minneapolis, MN 55401

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Gateway Electronics Of MO
8123-25 Page Blvd.
St. Louis, MO 63130

William Elec & Ind Supply
803 Davis Blvd.
Sikeston, MO 63801

New Jersey

Lashen Electronics Inc.
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Denville, NJ 07834

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Sylvan Wellington Co.
269 Canal Street
New York, NY 10013

R&E Electronics
4991 Rt. 209
Accord, NY 12404

Unicorn Electronics
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Johnson City, NY 13790

Ohio

Philcap Electronic Suppliers
275 E. Market Street
Akron, OH 44308

Oregon

Norvac Electronics
7940 SW Nimbus Avenue
Beaverton, OR 97005

Pennsylvania

Business & Computer Bookstore
213 N. Easton Road
Willow Grove, PA 19090

Texas

Mouser Electronics
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Mansfield, TX 76063

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1301 W Beltine
Carrollton, TX 75006

Electronic Parts Outlet
3753 B Fondren
Houston, TX 77063

GMD Electronics
2625 S. Loop Hwy.
Alvin, TX 77511

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Webster, TX 77598

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Amateur Radio Supply Co.
5963 Corson Ave., Ste 140
Seattle, WA 98108

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ANTHONY J. CARISTI

Increase fuel economy while improving your vehicle's performance

BUILD THE SMARTBOX

Operating the air conditioner in a vehicle is not free. It takes precious fuel to provide the horsepower that is demanded by the A/C compressor. Automotive manufacturers have helped reduce that demand by using a clutch system that allows the compressor to operate only when needed. In such systems, the A/C clutch is controlled by a pressure switch or thermostat that responds to the cooling needs of the passenger compartment.

In addition, the poorest fuel economy always occurs when the vehicle is accelerating or climbing a grade. On the other hand, very little fuel is used during coasting or braking. In fact, when the brakes are applied, the vehicle's kinetic energy—created by the engine to begin with—is purposely turned into heat and wasted. That acceleration/de-celeration sequence is repeated as the vehicle is driven.

Consider this: The load of the air-conditioning compressor is actually a benefit when decelerating and braking, since it helps stop the vehicle. At other times, it is an additional load on the engine, using extra fuel. Therefore, if the air conditioning compressor could be somehow turned off during heavy accelerating and allowed to run when needed the rest of the time, less fuel would be used to operate the A/C system.

The Smartbox described here helps synchronize the compressor with the load demand on the engine, so that the compressor is off when accelerating, and on when coasting or braking. When the Smartbox allows compressor operation, the A/C system is under its normal pressure switch/thermostat control. Without the added load of an A/C compressor when the engine is working extra hard, the Smartbox will save fuel.

An additional benefit provided by the Smartbox is to improve vehicle performance by temporarily disabling the compressor during acceler-

ation. With the compressor off, all available horsepower can be used to increase vehicle speed. That can be an important safety feature.

The Smartbox, contained on a small printed-circuit board, is easily connected to the wiring system of any vehicle. It is completely automatic in operation and never needs attention. The only operating control is an override switch that allows the driver of the vehicle to disable the Smartbox and return the A/C system back to its normal, unsynchronized operation. A pair of light-emitting diodes let you see what the Smartbox is doing at all times.

How it Works. The intake manifold of gasoline engines is always under a partial vacuum. Vacuum is sometimes expressed in inches of mercury, where a perfect vacuum is equal to about 30 inches. The level of vacuum produced in a gasoline-powered engine is always less than 30 inches, and varies with the load on the engine.

When idling, a gasoline engine will produce between 15 and 22 inches of vacuum. When the vehicle is cruising on a level roadway, the vacuum decreases to about 10 to 18 inches. When accelerating or climbing a hill, engine vacuum falls to less than 10 inches of mercury and can be close to zero during full-throttle conditions. The variation of engine vacuum can be used to directly measure how hard the engine is working. A special sensor is used by the circuit to measure engine vacuum, and that enables the Smartbox to determine under what conditions the vehicle is being driven.

About the Circuit. The schematic diagram for the Smartbox is shown in Fig. 1. The circuit is powered by a 12-volt source that is active only when the ignition of the vehicle is turned on. In that way, the Smartbox will not drain battery current when the vehicle is not being driven. Protection from voltage transients is provided by D1, R1, and C1. The supply voltage is regulated to 9 volts by IC1 for the remainder of the circuit. The Smartbox shows that the regulator is working by lighting LED1.

The heart of the Smartbox is SEN1, a modern solid-state differential-pressure sensor. That sensor is made up of a silicon substrate to which a set of piezo-resistors is attached. Those resistors are designed to change value if the substrate is stressed or bent in any way.

The silicon substrate creates two chambers. A port for each chamber lets positive or negative differences in pressure be measured by

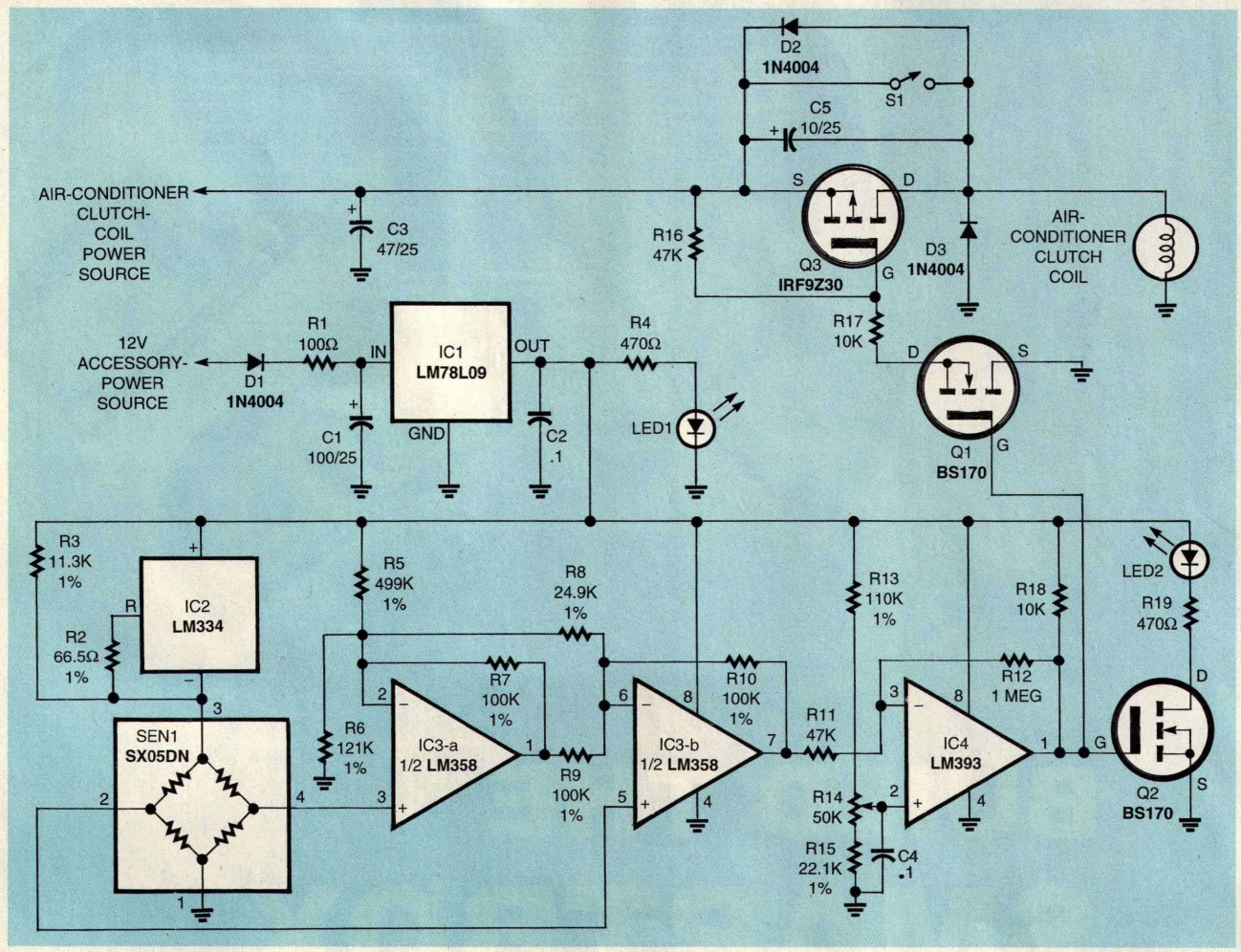


Fig. 1. The Smartbox senses when an automobile's engine is working hard, and cuts out the air-conditioner compressor to improve performance and save money. Using metal-film resistors makes the circuit stable over a wide temperature range.

the sensor. For the Smartbox, one port is exposed to the atmosphere as a reference, and the other is connected to the engine's intake manifold by means of a rubber hose. That lets the sensor respond to variations in engine vacuum.

The resistors within the sensor are wired together in a Wheatstone-bridge configuration. The values of the resistors are such that the bridge is balanced when no stress is placed upon the substrate. Any pressure difference between the two chambers of the sensor caused by engine vacuum will result in mechanical stress being placed upon the substrate, and thus produce a predictable amount of bridge unbalance.

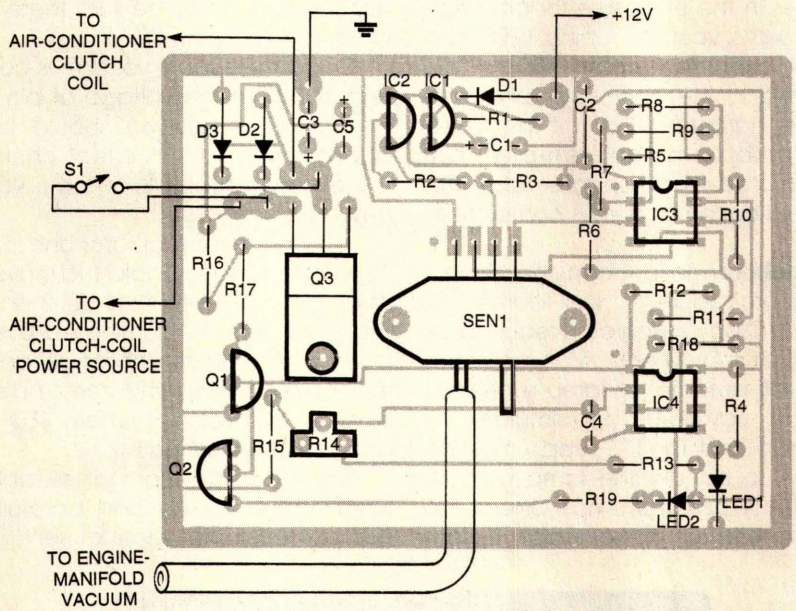


Fig. 2. Use this parts-placement diagram when building the Smartbox. Pay close attention to the orientation of polarized components, especially SEN1.

The sensor resistors are driven by a temperature-compensating constant-current source provided by IC2, R2, and R3. The differential output of the sensor, measured between terminals 2 and 4, will be 90 millivolts or more during normal cruising conditions. When the engine is called upon to deliver more power, the voltage will drop below 90 millivolts as determined by the throttle setting and load on the engine.

The output of SEN1 is amplified by IC3. The two sections of IC3 are configured as a differential amplifier with a gain of 10. The gain is set by resistors R5–R10. A 1.8-volt offset is created by R5 and R6. That offset voltage is added to the sensor voltage. Thus, the output voltage of the amplifier, measured at pin 7 of IC3, is at 2.7 volts during normal cruising conditions. That voltage represents the load on the engine, and will vary with throttle position.

The output of IC3-b is connected to the positive input to IC4, a voltage comparator. The negative input of IC4 is set to a reference voltage by R13, potentiometer R14, and R15. The use of potentiometer R14 lets the Smartbox be calibrated to any particular vehicle for the best balance between economy and performance. Since the output voltage at pin 7 of IC3-b will decrease as engine load increases, R14 can be set to the neutral point between cruising and accelerating.

When the Smartbox calls for compressor operation, the output of IC4 will be about 9 volts. That turns on Q1, which in turn activates Q3 through voltage divider R16 and R17. At the same time, Q2 is activated, illuminating LED2.

The Smartbox turns the compressor on and off with Q3, a P-channel power MOSFET. The source terminal of Q3 is driven by the compressor-clutch feed wire, and the drain terminal is connected to the clutch coil. As IC4 switches back and forth between 0 and 9 volts, the A/C compressor of the vehicle will be under control of the Smartbox as indicated by LED2. However, under cruising conditions, the compressor will still cycle in accordance with the A/C system's pressure switch/thermostatic control.

During a sustained hill-climb or when starting the vehicle after it has been parked in full sunlight, it might be desirable to have full-compressor operation. An override switch, S1, has been provided to allow the A/C system to generate full cooling power regardless of engine operating conditions.

Construction. The Smartbox circuit is not critical and may be hard-wired on a perfboard using good construction techniques. Alternatively, a foil pattern for a single-sided PC board is provided. If desired, an etched and drilled PC board is available from the source given in the Parts List.

If you use a PC board from the foil pattern or from the source given in the Parts List, follow the parts-placement diagram in Fig. 2 for component location.

For maximum reliability under the various conditions of vibration present in a vehicle, it is recommended that the integrated circuits be soldered directly to the circuit board. Be sure to install all polarized components with the correct orientation. One part placed backwards in the circuit will prevent the Smartbox from working and could cause damage to one or more components.

For circuit accuracy and stability be sure to use metal-film resistors where specified in the Parts List. Ordinary carbon resistors are not temperature stable and should not be used in place of metal-film types.

Although Q3 is a power transistor that will handle the current for the A/C clutch, it operates relatively cool so no heat sink is required. It should be mounted to the board with a machine screw and nut.

The pressure sensor is mounted

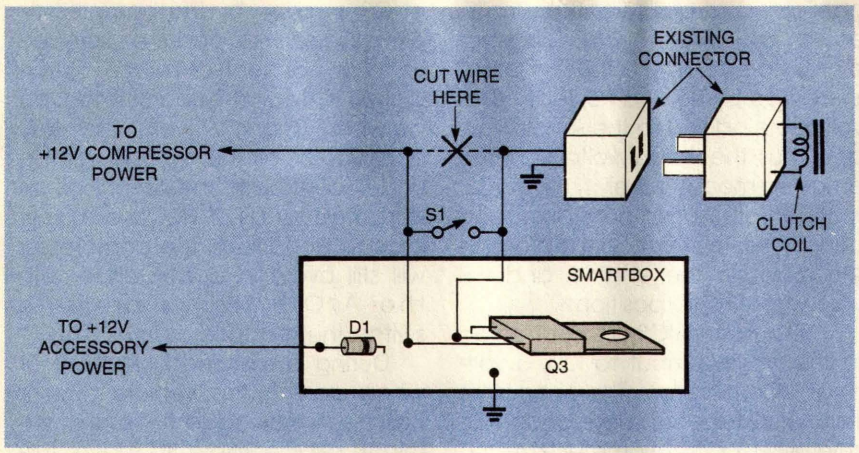


Fig. 3. Here's a typical Smartbox installation. Double-check the voltage polarities of the clutch-coil wire. If your vehicle supplies power to the clutch and turns the ground on and off, the wires to the Smartbox will have to be reversed. Hooking up the clutch wires backwards will destroy D2 and possibly Q3.

directly on the board. Care should be taken when handling the pressure sensor. Note the location of pin 1, which is designated by a small dot printed on its housing. Once the proper orientation of SEN1 is determined, bend the four leads gently, so that they are at right angles with the body of the part. Avoid placing stress on the terminals where they enter the housing. Use suitable hardware or RTV silicone-rubber adhesive to secure the sensor to the board. If screws are used to mount SEN1, do not overtighten them. Excessive stress on the sensor's plastic case might cause it to crack, destroying the sensor.

Four connecting wires are required, which should be no smaller than 16-gauge insulated stranded wire. Use different colors if possible to help avoid wiring errors. Be sure to allow sufficient lead length for the two clutch wires, which must pass through the firewall to the engine compartment of the vehicle.

When the printed circuit board is completed, examine it very carefully for opens, short circuits, and bad solder connections that might appear as dull blobs of solder. Any solder joint that is suspect should be redone by removing the old solder with desoldering braid, cleaning the joint, and carefully applying new solder. It is far easier to correct any possible problems at this stage rather than later if you discover that the Smartbox does not work.

The printed-circuit board should be placed into a small enclosure for protection against dust and dirt. Drill holes in the enclosure for connecting wires, vacuum tubing, LEDs, and the override switch. Mount the board in the enclosure using suitable hardware. Do not install the Smartbox in the vehicle until instructed to do so later, after the checkout procedure is completed.

Checkout. To perform the checkout procedure, a well-filtered 12-volt DC power source is required, as well as a DVM or VOM. A common 12-volt automotive lamp such as a #1157 may be used to simulate the clutch load. The DC supply must be able to handle the lamp current, which is about 3 amps. Check the lamp with the power supply, before starting, to be sure that they both work.

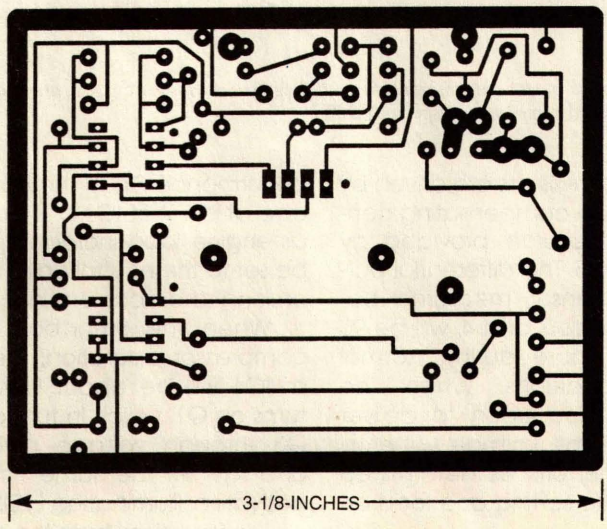
Connect the test lamp to the clutch wire of the circuit (drain of Q3), and circuit common. Apply 12-volt power to the accessory lead (anode of D1), and the clutch-power lead (source of Q3). Be sure to observe proper polarity. The voltage at the output terminal of IC1 should be 9 volts, and LED1 should be illuminated.

If the 9-volt reading is either too high or low, or the LED is not illuminated, remove power. Troubleshoot the circuit and correct the fault before proceeding with the checkout. Check the orientation of D1, C1, C2, C3, LED1, IC1, IC2, IC3, and IC4. Measure the resistance between the 9-volt power bus and circuit common to be sure there is no short circuit.

Once the supply voltage is correct, measure the voltage at pin 3 of SEN1. The reading should be about 6 volts. If it is incorrect, check the orientation of IC2, and the values of R2 and R3.

With the 9-volt regulator and IC2 operating properly, adjust R14 over its range and verify that LED2 and the test lamp are illuminated over part of the adjustment range, and extinguished over the remainder. Set R14 to the point where LED 2 and the lamp just go off.

Now take a length of suitably sized rubber tubing and carefully place it over the vacuum sensing



Here's the foil pattern for the Smartbox. The circuit is simple enough to fit onto a single-sided PC board.

PARTS LIST FOR THE SMARTBOX

SEMICONDUCTORS

IC1—LM78L09 voltage regulator, integrated circuit
IC2—LM334Z constant-current regulator, integrated circuit
IC3—LM358N dual op-amp, integrated circuit
IC4—LM393N dual comparator, integrated circuit
D1–D3—1N4004 silicon diode
LED1, LED2—Light-emitting diode, red
Q1, Q2—BS170 N-channel MOSFET transistor
Q3—IRF9Z30 P-channel MOSFET transistor

RESISTORS

(All resistors are ¼-watt, 1% metal-film units, unless otherwise noted.)
R1—100-ohm, ¼-watt, carbon-composition
R2—66.5-ohm
R3—11,300-ohm
R4, R19—470-ohm, ¼-watt, carbon-composition
R5—499,000-ohm
R6—121,000-ohm
R7, R9, R10—100,000-ohm
R8—24,900-ohm
R11, R16—47,000-ohm, ¼-watt, carbon-composition
R12—1-megohm, ¼-watt, carbon-composition
R13—110,000-ohm
R14—50,000-ohm potentiometer
R15—22,100-ohm
R17, R18—10,000-ohm, ¼-watt, carbon-composition

CAPACITORS

C1—100-µF, 25-WVDC, electrolytic
C2, C4—0.1-µF, ceramic-disc
C3—47-µF, 25-WVDC, electrolytic
C5—10-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

S1—SPST toggle switch
SEN1—SX05DN differential pressure sensor (SenSym)
Enclosure, hookup wire, rubber vacuum tubing, etc.

Note: The following items are available from: A. Caristi, 69 White Pond Road, Waldwick, NJ 07463: Etched and drilled PC board, $9.50; SEN1, $38.75; IC1, $2.00; IC2, $5.75; IC3, $2.00; IC4, $2.00; Q1, $2.00; Q2, $2.00; Q3, $7.75. Please add $5.00 postage/handling. SEN1 is also available from: SenSym, 1804 McCarthy Blvd., Milpitas, CA 95035, Tel: (408) 954-1100.

port of the pressure sensor as indicated in Fig. 2. Apply suction to the open end of the tubing with your mouth and note that it is possible to cause LED2 and the test lamp to light. If they remain lighted when the vacuum is removed from the tubing, gently apply pressure to the tubing to cause the LED and lamp to become extinguished again.

If you obtain the results outlined above, the checkout procedure is completed. If the circuit is not operational, verify that the tubing is attached to the vacuum port of the sensor. The voltage at pin 7 of IC3 should normally be about 1.8 volts, and should increase as vacuum is applied to the sensor. If it does not, check IC3 and all components associated with it.

If the sensor and IC3 are operating correctly, check the output voltage of IC4. It should switch between 9 volts and 0 as R14 is adjusted over its range. If that does not happen, check the orientation of Q1, Q2, D2, D3, and LED2. The values of R16 and R17 should also be checked. If everything else checks out, the transistors might need to be replaced.

Check the voltage at pin 2 of IC4 as R14 is rotated over its range to verify that it can be set both above and below the voltage at pin 7 of IC3. If not, check R13, R14, and R15. When pin 1 of IC4 switches to 9 volts, the test lamp is energized through Q1 and Q3, and LED 2 is activated by Q2.

Installation and Final Adjustment. One final adjustment needs to be made before the Smartbox is permanently mounted in the vehicle. A typical installation in Fig. 3 shows how the Smartbox is connected to the electrical system of a vehicle. You must locate the cable harness that feeds the compressor-clutch coil, and a 12-volt accessory wire located anywhere in the vehicle.

To make the final calibrating adjustment, connect the 12-volt accessory lead (anode of D1) to any wire that is powered only when the ignition of the vehicle is turned on. Such a wire can be identified by using a DC voltmeter to verify power as the ignition switch is turned to the on position. Possible choices are connections to the radio, windshield-wiper motor, or A/C-blower circuit.

The ground lead from the Smartbox can be connected to any metal part of the vehicle. You can either use an existing screw (cleaning the metal parts thoroughly) or drill a hole for a no. 8 sheet-metal screw. The remaining two wires of the Smartbox are fed through the firewall into the engine compartment.

Locate the power-feed cable to the compressor clutch, which usually has a two-wire connector that is plugged into the compressor assembly. One of the wires is ground and the other is the power feed. Cut only the power feed line at a convenient location. The insulation on each cut end is to be stripped back about $^3/_8$-inch. Identify those ends as "power feed" and "clutch."

Connect the wire from the source of Q3 to the power-feed wire. The connection should be soldered and taped securely. The remaining wire from the connector is tied to the drain of Q3. Again, solder and insulate the connection carefully with electrical tape.

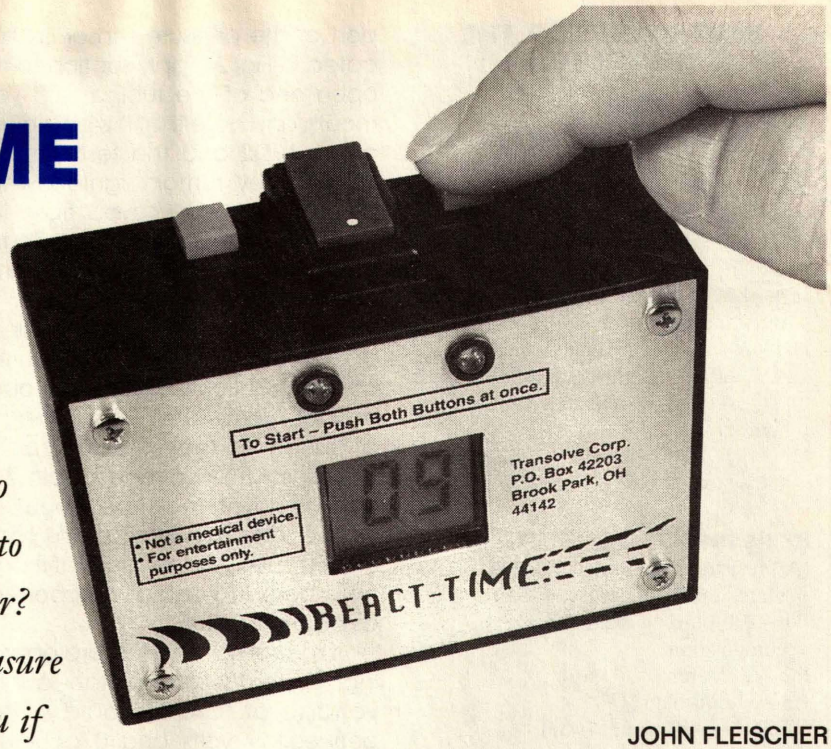
The last connection to Smartbox is the vacuum tubing. Find a source of raw engine vacuum that is not regulated in any way, such as the input side of the vacuum storage container for the heater/air-conditioning controls. Since today's vehicles have a multitude of vacuum-hose connections, you may wish to consult a chassis manual or your local auto mechanic to identify the proper vacuum source. Cut the line squarely at a convenient location, insert a "tee"-type hose splice, and attach the Smartbox's vacuum tubing to the third connection.

The final adjustment of R14 must be made under actual driving conditions with the A/C operating and the blower at high speed. That is best done on a warm or hot day. Choose a level stretch of highway for the adjustment procedure. For obvious safety reasons, an assistant should drive the vehicle as you calibrate the circuit.

Bring the vehicle up to a steady 55 MPH and adjust R14 so that LED2

(Continued on page 49)

BUILD THE REACT-TIME TESTER



Do you sometimes feel you're too tired, ill, or under the weather to operate machinery or drive a car? The React-Time Tester can measure your reaction time and show you if you're slowing down—even if you still feel fine.

JOHN FLEISCHER

The human brain is more powerful than the largest computer. Unfortunately, it doesn't have any built-in diagnostics or an umbilical plug for servicing. Often, a police officer or physician might need to test a person's brain function to determine if any coordination impairment exists. Brain performance can be affected by fatigue, drugs, injury, or old age. Various mental tests are used, some of which involve orientation, memory, attention, vigilance, learning, visual/audio perception, reasoning, language ability, and reaction time.

Reaction time is the interval between the application of a stimulus and the beginning of a response. Simple- and complex-reaction testing is regarded as a good indicator of cerebral integrity. Simple-reaction testing (response to a single visual or audible stimulus) reflects the level of "vigilance" of the central nervous system. Complex-reaction testing (response to different stimuli) measures the speed of decision making and response selection. The slowing of complex reactions is probably the most sensitive currently available behavioral index of advanc-

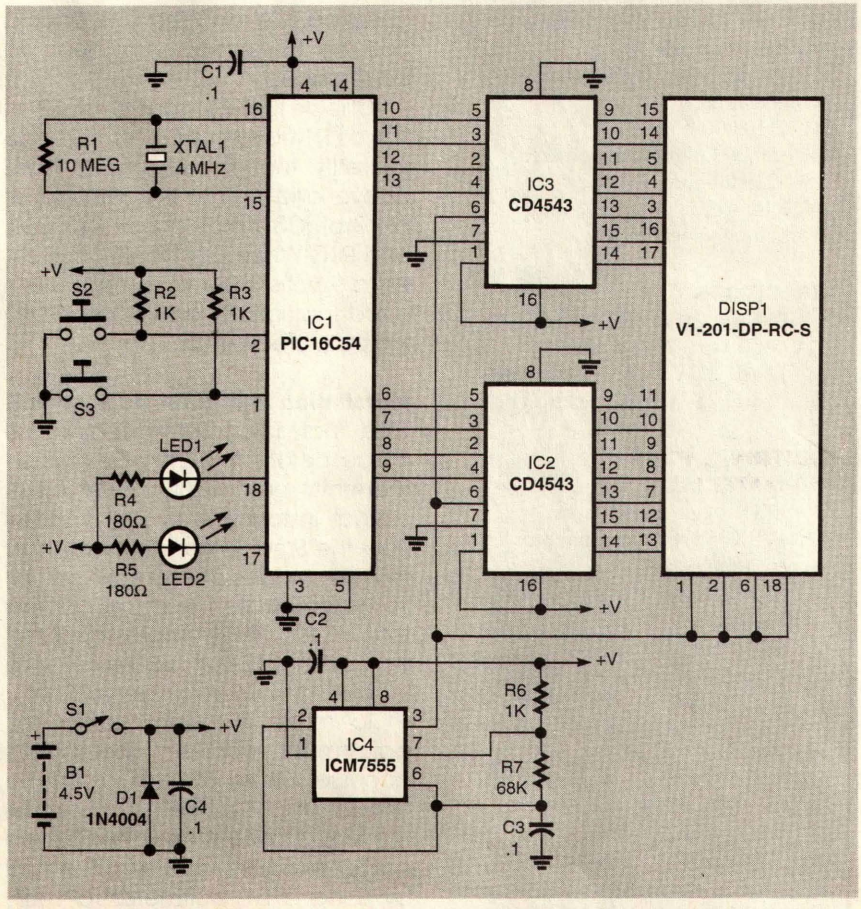


Fig. 1. The React-Time tester is a hand-held computer that measures reaction time. Using a programmed PIC microcontroller lets the actual hardware be very simple.

ing age in normal people. An older person typically has a reaction time that is 80 ms slower than that of a young person.

An interesting roadside survey of 240 young male nighttime drivers was done in 1994 by the Glostrup Police Department in Denmark. The study consisted of a questionnaire with self-assessment of tiredness followed by a simple visual-stimulus reaction-time test. The results of the response test matched up closely with the drivers, self-assessed level of fatigue. The data shows the validity of reaction testing and is proof that driving while tired is dangerous.

Just about all drugs (including alcohol) will increase reaction time. That effect may not be completely perceived by the affected person, explaining the many accidents involving drunk drivers.

Reaction-time testing has practical uses and can be a lot of fun. The React-Time tester presented here is not a medical-grade device, but is intended for hobby and entertainment purposes only. Try it on your friends!

How it Works. The circuit for the React-Time, which is shown in Fig. 1, is built around IC1, a PIC controller. That controller, and the software program burned into it, controls LED1 and LED2, measures the time it takes to press S2 and S3, and displays the results on DISP1. The display information is converted to a pair of BCD-to-seven-segment converters, IC2 and IC3. Liquid-crystal displays require a low-frequency squarewave in order to operate. A 100-Hz squarewave is generated by IC4 for the display.

When the unit is first turned on, the liquid-crystal display displays "00." To start a test, both buttons are pushed. The unit counts down from three. After a random delay, one or both LEDs are lit up. In order to turn a light off, the switch above the light must be pressed. The time delays between lighting the LEDs and pressing the buttons for nine tests are added together and displayed on the LCD as a number between 1 and 99.

The React-Time tester performs a complex-type reaction test that requires a decision. Three important body organs are involved in the test: the eye, the brain, and the hand. When you see light from the LEDs, your brain has to choose which buttons to press. The needed neuromuscular command is then sent to the hand. That takes a finite time that the React-Time can easily measure.

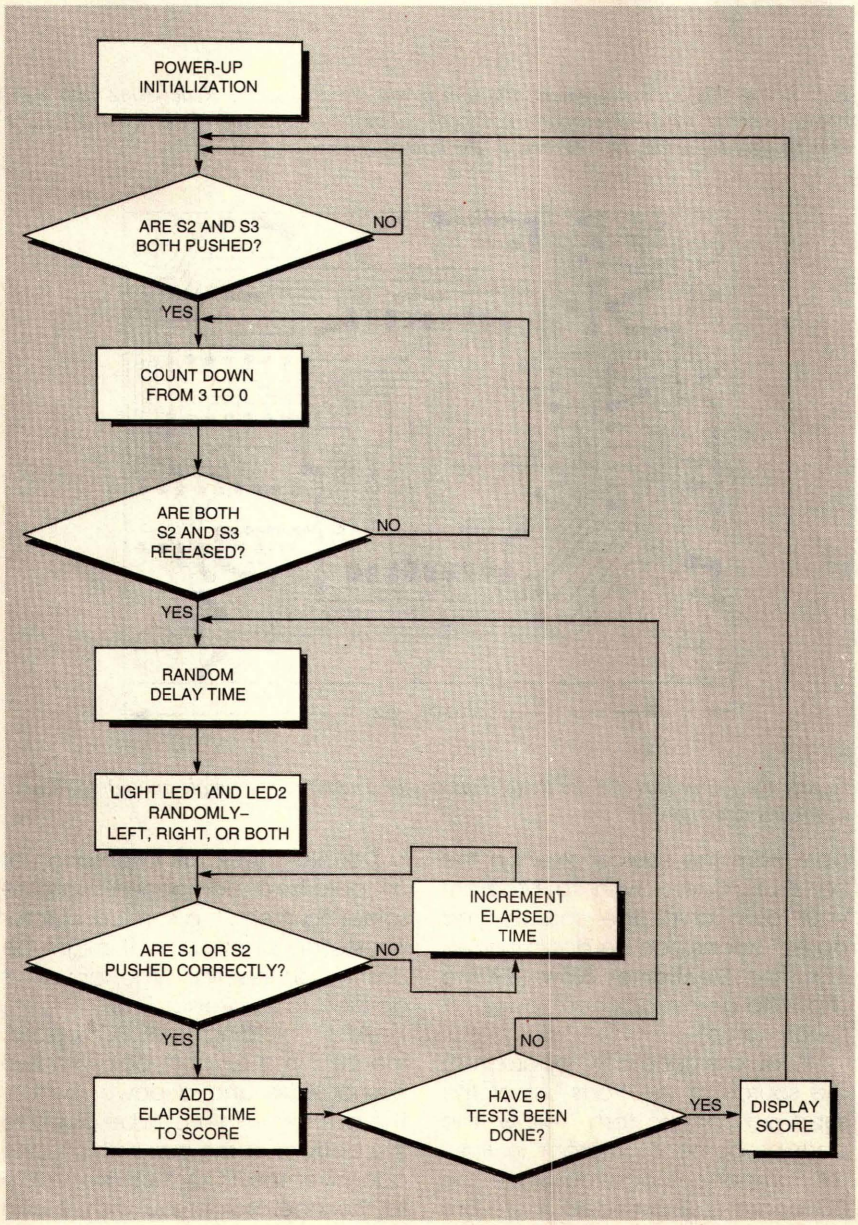


Fig. 2. The software for the React-Time follows this flowchart. It is simply a large loop that performs the test when triggered by pressing S2 and S3 together.

Software. The PIC chip must be programmed with the React-Time program before it can be used. Figure 2 shows the flow of the program. When the unit is turned on, the React-Time waits for both switches to be pressed to start a session. After a 3-second countdown, the switches are checked again. If they have been released, nine tests are performed. Each test waits a random amount of time and then the LEDs are lighted at random in one of three possible patterns. The elapsed time is counted until the proper switches are pressed. The elapsed times from nine tests are added together, and the result displayed. The program then loops back to the start of the program and waits for both switches to be pressed.

Construction. The React-Time can be built on perfboard with wirewrap or point-to-point connec-

PARTS LIST FOR THE REACT-TIME TESTER

SEMICONDUCTORS

IC1—16C54-RC/P microcontroller, integrated circuit
IC2, IC3—CD4543BE BCD-to-7-segment display decoder, integrated circuit
IC4—ICM7555IPA timer, integrated circuit
D1—1N4004 silicon diode
LED1, LED2—Super-bright light-emitting diode (Mouser 512-MV8112 or similar)
DISP1—2-digit liquid-crystal display, Varitronix VI-201-DP-RC-S (Digi-Key 153-1003-ND or similar)

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—10-megohm
R2, R3, R6—1,000-ohm
R4, R5—180-ohm
R7—68,000-ohm

CAPACITORS

C1–C4—0.1-μF, ceramic disc

ADDITIONAL PARTS AND MATERIALS

B1—4.5 volts, 3 AA batteries
S1—Single-pole, single-throw switch (Mouser 103-R13-49A or similar)
S2, S3—Normally-open, momentary contact (Mouser 103-1210 or similar)
XTAL1—4-MHz crystal (Digi-Key X006 or similar)
LED bushings, printed-circuit board, battery holder, case, hardware, etc.

Note: The following items are available from: Transolve Corp., PO Box 42203, Brookpark, Ohio 44142: Printed-circuit board, $8.00; Pre-programmed IC1, $8.00; Complete kit of all parts, $41.00; Assembled and tested unit, $51.00; Software documentation package, $2.00. Please include $4.00 shipping charges to US, $6.00 to Canada, and $8.00 for foreign orders. Ohio residents must add appropriate sales tax. Information on PIC programmers is available from: Parallax, Inc., 3805 Atherton Rd. #102, Rocklin, CA 95765. Tel: (916) 624-8333.

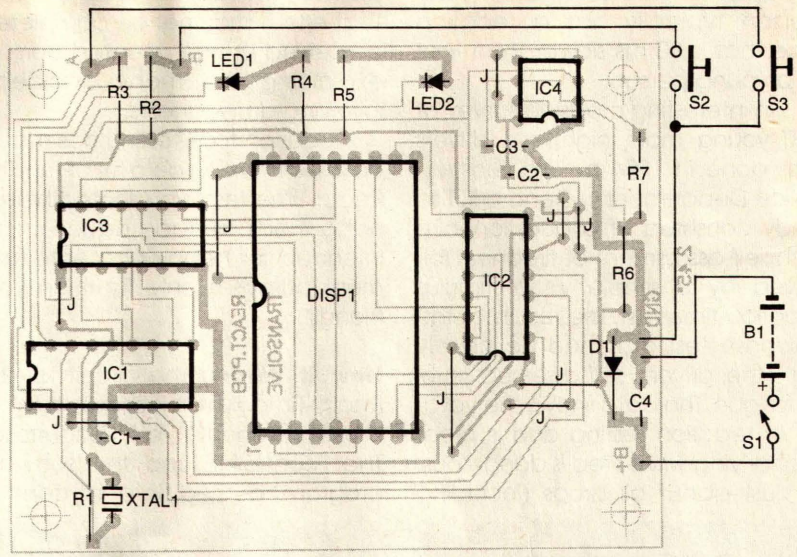
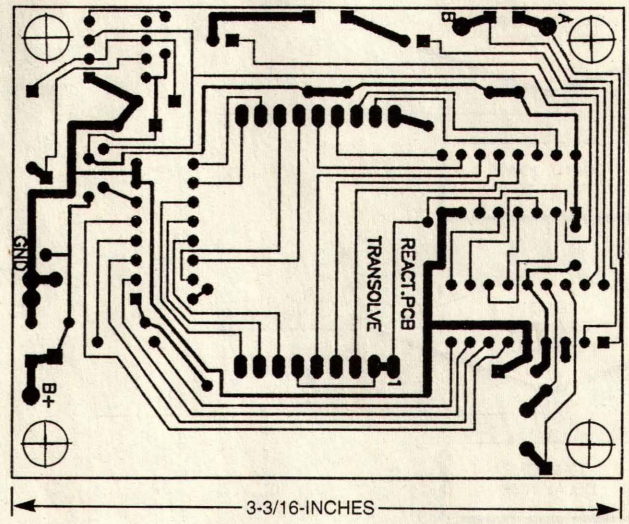


Fig. 3. Use this parts-placement diagram if you're building the React-Time with a PC board from the provided foil pattern. Be careful of the orientation of the ICs and DISP1. Don't forget to install the jumpers, or the board won't work.



Here is the foil pattern for the React-Time tester. The circuit is simple enough to fit onto a single-sided board.

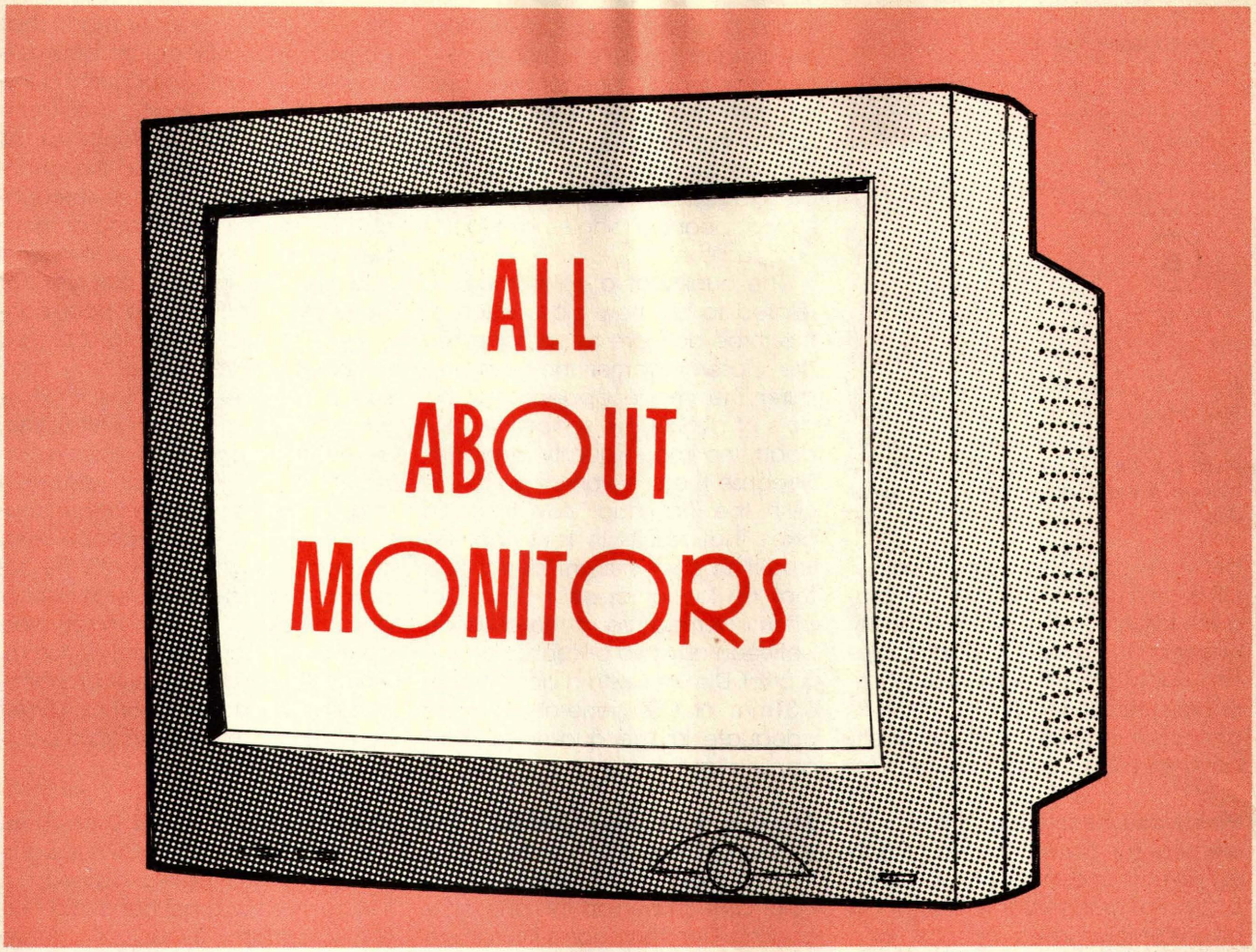
tions. For a neater project appearance, a PC board can either be etched or purchased from the source given in the Parts List. A foil pattern for a single-sided board has been supplied.

The PIC chip must be programmed with the React-Time software before it is installed in the unit. A pre-programmed chip is available from the source given in the Parts List. If you wish to program your own chip, the source and object codes can be downloaded from the **Electronics Now** FTP site (ftp://ftp.gernsback.com/pub/EN/reactime.zip).

If you are using a PC board from the source in the Parts List or the supplied foil pattern, follow the parts-placement diagram in Fig.3 for component location. Since the PC board is single-sided, there are a number of jumpers that must be installed for the unit to work properly. Double-check the orientation of all polarized components before soldering them. If a semiconductor is installed backwards, it might be destroyed the first time power is applied to the React-Time.

After building the PC board, mount it in a suitable box with two pushbuttons and a power switch. The battery holder can be glued to the bottom of the box with silicone adhesive. The LCD must be visible to the operator. If you wish, it can be protected by cementing a thin

(Continued on page 41)



Here's a look behind the screens of one of the most important, yet often overlooked, parts of a personal computer

STEPHEN J. BIGELOW

No matter how fast and powerful your PC may be, it serves little purpose without a monitor. For most computer users, the monitor is usually left as an afterthought, or something that's just "included" with the PC purchase. Yet, monitors play a surprisingly important role in the modern computer. They are the window into a computer's world. Video clips, word processing, web browsing, presentation development—virtually every application we use a computer for will depend on the presence of a working monitor. As a result, we can choose from an astonishing variety of monitor types, sizes, and qualities—all of which have an effect on how long (and how well) we use our computers. This article explains the essential concepts of a computer monitor, and shows you what's inside.

The first step in understanding computer monitors is to understand the terms and concepts essential for monitor operation. Let's go though those next.

The CRT. The *Cathode Ray Tube* (called a "CRT" or "screen") is essentially a large vacuum tube. One end of the CRT is formed as a long, narrow neck, while the other end is a broad, almost-flat surface. A phosphor coating is applied inside the CRT along its front face. The neck end of the CRT contains an element (called the *cathode*) which is energized and heated to very high temperatures (much like an incandescent lamp). At high temperatures, the cathode liberates electrons. When a very high positive voltage is applied at the front face of the CRT, electrons liberated by the cathode (which are negatively charged) are accelerated toward the front face. When the fast-moving electron strikes the phosphor on the front face, light is produced. By directing the stream of electrons across the front face, a visible image can be produced. Of course, there are other elements needed to control and direct the electron stream, but this is CRT operation in a nutshell.

CRT face size (or *screen size*) is generally measured as a diagonal dimension—that is, a 43.2cm (17-inch) CRT is 43.2cm (17 inches)

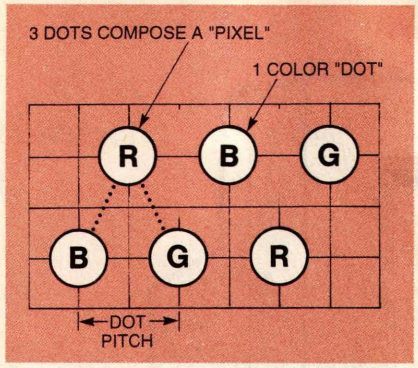


Fig. 1. In a color monitor, red, green and blue phosphor dots are arranged in a "triad" configuration. Each triad is one pixel, and the dot pitch specification of a monitor is the distance between phosphor dots.

between *opposing* corners. Larger CRTs are more expensive, but produce larger images that are usually easier on the eyes. A CRT specification will also list the type of phosphor(s) used (*i.e.* P22), in addition to anti-glare (or any special finish) coatings used during manufacture.

Pixels and Resolution. The picture element (or *pixel*) is the very smallest point that can be controlled on a CRT. For monochrome displays, a pixel is simply turned on or off. For a color display, a pixel could also assume any of a number of different colors. Pixels are combined in the form of an array (rows and columns), and it is the *size* of that pixel array that defines the display's *resolution*. As a result, resolution is the total number of pixels in width by the total number of pixels in height. For example, a typical EGA resolution is 640 pixels wide by 350 pixels high, while a standard VGA resolution is 640 pixels wide by 480 pixels high. Typical super VGA (SVGA) resolution is 800 pixels wide by 600 pixels high and higher. Resolution is important for computer monitors since higher resolutions allow finer image detail.

While monochrome CRTs use a single, uniform phosphor coating (usually white, amber, or green), color CRTs use three color phosphors (red, green, and blue) arranged as triangles (or *triads*). Figure 1 illustrates a series of color phosphor triads. On a color monitor, each triad represents one pixel (even though there are three *dots* in the pixel). By using the electron streams from three electron guns—one gun for red, one for blue, and another for green—to excite each dot, a broad spectrum of colors can be produced. The three dots are placed so close together that they appear as a single point to the unaided eye.

The quality of a color image is related to just how close each of the three dots are to one another. The closer together they are, the purer the image appears. As the dots of a pixel are spaced further apart, the image quality degrades because the eye can begin to discern the individual dots in each pixel. That results in lines that no longer appear straight and colors that no longer appear pure. *Dot pitch* is a measure of the distance between any two phosphor dots in a pixel. Displays with a dot pitch of 0.31mm or less generally provide adequate image quality for most applications

Shadow and Slot Masks. The *shadow mask* is a thin sheet of perforated metal that is placed in the color CRT just behind the phosphor coating. Electron beams from each of the three "electron guns" are focused to converge at each hole in the mask—**not** at the phosphor screen. The microscopic holes act as apertures that let the electron beams through **only** to their corresponding color phosphors. In that way, any stray electrons are *masked*, and color is kept pure. Without a mask, stray electrons from one electron beam may accidentally excite nearby color phosphors, resulting in unwanted color combinations. Some CRT designs substitute a shadow mask with a *slot mask* (or *aperture grille*) that is made up of vertical wires behind the phosphor screen. Keep in mind that monochrome CRT designs do not use a mask since the entire phosphor surface is the same color.

Convergence. Remember that we said earlier that *three* electron guns are used in a color monitor—each gun excites a particular color phosphor. All three electron beams are tracking around the screen simultaneously, and the beams converge at holes in the shadow mask. That *convergence* of electron beams is closely related to color purity in the screen image. Ideally, the three beams converge perfectly at all points on the mask, and the resulting color is perfectly pure throughout (*i.e.* pure white). If one or more beams do not converge properly, however, the image color will not be pure. In most cases, poor convergence will result in colored shadows. For example, you may see a red, green, or blue shadow when looking at a white line. Serious convergence problems can result in a blurred or distorted image. Monitor specifications usually list typical convergence error as *misconvergence* at both the display center and the overall display area. Typical center misconvergence runs approximately 0.45mm, while overall display area misconvergence is about 0.65mm. Larger numbers than those indicate poorer convergence.

Pincushion and Barrel Distortion. The front face of most CRTs is slightly convex (bulging outward). Images, on the other hand, are perfectly square. When a square image is projected onto a curved surface, distortion results. Ideally, a monitor's raster circuits (discussed below) will compensate for the screen shape so that the image appears square when viewed at normal distances. In actual practice, however, the image is rarely

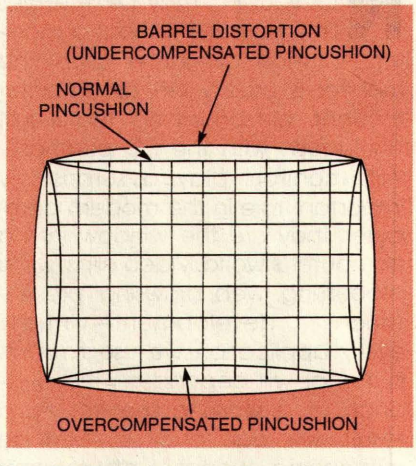


Fig. 2. Pincushion and barrel distortion occur when the displayed image deviates from square. Pincushion is used to describe an inward bend, while barrel is used to describe an outward bend.

square. The sides of the image (top-to-bottom and left-to-right) may be bent slightly inward or slightly outward. An exaggerated view of those effects is shown in Fig. 2.

Pincushioning occurs when sides are bent inward making the image's border appear concave. Other straight lines within the image may also appear to curve toward the image center. *Barreling* occurs when the sides are bent outward making the image's border appear convex. Straight lines in the image may appear to bend outward toward the edges of the screen. In a properly aligned monitor, those distortions should be just barely noticeable (no more than 2.0 or 3.0 mm). Note that barrel distortion is sometimes also referred to as *pincushioning* as well.

Horizontal Scanning, Vertical Scanning, Raster, and Retrace. To understand what *scanning* is, you must first understand how a monitor's image is formed. A monitor's image is generated one horizontal line of pixels at a time starting from the upper left corner of the display (see Fig. 3). As the beams travel across the line, each pixel is excited based on the video data contained in the corresponding location of video RAM on the video-adapter board. When a line is complete, the beams turn off (or *horizontal* blank) and are directed horizontally (and slightly vertically) to the beginning of the next line. A new horizontal line can then be drawn. That process continues until all horizontal lines are drawn and the beam is in the lower right corner of the display. When the image is complete, the beams turn off (or *vertical* blank) and are redirected to the upper left corner of the display to start all over again. The rate at which horizontal lines are drawn is known as the *horizontal scanning rate* (sometimes called *horizontal sync*). The rate at which a complete "page" of horizontal lines is generated is known as the *vertical scanning rate* (or *vertical sync*). Both the horizontal and vertical blanking times are known as *retrace times* since the deactivated beams are "retracing" their path before starting a new trace. A typical horizontal retrace time is 5ms, while the typical vertical retrace time is 700 ms (though these times will vary depending on the screen resolution being used). This continuous horizontal and vertical scanning action is known as *raster*.

We can apply numbers to scanning rates to give you an even better idea of their relationship. A typical VGA monitor with a resolution of 640 × 480 pixels uses a horizontal scanning rate of 31.5 kHz. That rate means that 31500 lines can be drawn in 1 second, or a single line of 640 pixels can be drawn in 31.7 μS. Since there are 480 horizontal lines to be drawn in one "page," a complete page can be drawn in (480 × 31.7 μS) 15.2 ms. If a single page can be drawn in 15.2 ms, the screen can be refreshed 65.7 times per second (65.7 Hz)—this is roughly the vertical rate that will be set for VGA operation at 640 × 480 resolution. In actual practice, the vertical scanning rate will be set to a whole number such as 60 Hz, which leaves a lot of spare time for blanking and synchronization. It was discovered early in TV design that vertical scanning rates under 60 Hz resulted in perceivable flicker, which causes eye strain and fatigue. You can start to see now that horizontal scanning rates are **not** chosen arbitrarily. The objective is to select a horizontal frequency that will cover a page's worth of horizontal pixel lines for any given resolution at *about* 60+ times per second. Newer monitor designs are now using vertical scanning rates of 72 to 80 Hz. Table 1 compares the scanning rates for current monitor resolutions.

Interlacing. Table 1 introduces another important concept of horizontal scanning known as *interlacing*. Images are "painted" onto a display one horizontal row at a time, but the sequence in which those lines are drawn can be non-interlaced or interlaced. A *non-interlaced* monitor draws all of the lines that compose an image in *one* pass (such as the pattern in Figure 3). This is preferable since a non-interlaced image is easier on your eyes—the entire image is refreshed at the vertical scanning frequency—so a 60-Hz vertical scanning rate will update the entire image 60 times in 1 second. An *interlaced* display draws an image as *two* passes. Once the first pass is complete, a second pass fills in the rest of the image. The *effective* image refresh rate is only half the stated vertical scanning rate. The typical 1024 × 768 SVGA monitor of Table 1 shows a vertical scanning rate of 87 Hz, but since the monitor is interlaced, *effective* refresh is only *43.5 Hz* and screen flicker is much more noticeable.

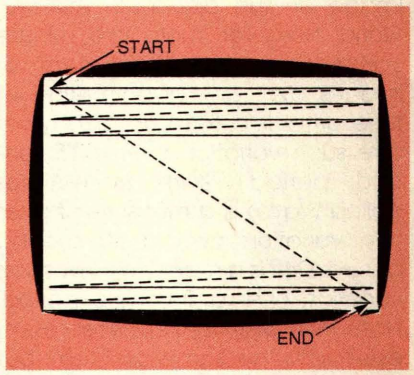


Fig. 3. A typical raster pattern is shown here. The scan pattern begins in the upper left-hand corner, ends in the lower right-hand corner, then returns to the beginning during the vertical blanking interval.

Bandwidth. In the very simplest terms, the *bandwidth* of a monitor is the absolute maximum rate at which pixels can be written to the display. Typical VGA displays offer a bandwidth of 30 MHz. That is, the monitor could generate up to 30 million pixels per second on the display. Consider that each scan line of a VGA display uses 640 pixels, and the horizontal scan rate of 31.45 kHz allows 31450 scan lines per second to be written. At that rate, the monitor is processing (640 pixels/scan line × 31450 scan lines/second) 20,128,000 pixels/second—well within the monitor's 30-MHz bandwidth. The very newest high-resolution color monitors offer bandwidths of 135 MHz. Such high-resolution 1280 × 1024 monitors with scanning rates of 79 kHz would need to process at least (1280 pixels/scan line × 79000 scan lines/second) 101,120,000 pixels/second (101.12 MHz), so enhanced bandwidth is truly a necessity.

Swim, Jitter, and Drift. The electron beam(s) that form an image

are directed around a display using variable magnetic fields generated by separate vertical and horizontal *deflection coils* mounted at the CRT's neck. The analog signals that drive each deflection coil are produced by horizontal and vertical deflection circuitry (which you will learn more about later). Ideally, deflection circuitry should steer the electron beam(s) precisely the same way in each pass. This would result in an absolutely rock-solid image on the display. In the real world, however, there are minute variations in the placement of images over any given period of time. *Jitter* is a term used to measure such variation over a 15 second period. *Swim* (sometimes called Wave) is a measure of position variation over a 30 second period. *Drift* is a measure of position variation over a 1 minute period. Note that all three terms represent essentially the same problem, but over different amounts of time. Swim, jitter, and drift may be expressed as fractions of a pixel or as physical measurements such as millimeters.

Brightness. When an electron beam strikes phosphor, light is liberated. The *brightness* of an image indicates how much light is generated when an image is formed. Brightness is measured in foot-Lumens (*fL*). While the actual physics of fL and brightness are beyond the scope of this article, simply consider that most monitors provide visible brightness levels of 50 to 60fL depending on the CRT's brightness setting, and how much white is contained in the overall image. Larger numbers indicate brighter displays, while smaller numbers suggest dimmer displays (*i.e.* background raster is usually about 0.3fL). Keep in mind that brightness is typically measured with a pure white square shown in the center 20% of the display. Not all monitors provide a specification for brightness, since it is a difficult and rather subjective quantity to measure—precise scientific instrumentation is needed for an accurate measurement.

Synchronization and Polarity. After a line is drawn on the display, the electron beams are turned off (blanked) and repositioned to start the next horizontal line. However, no data is contained in the retrace line. In order for the new line to be "in sync" with the data for that line, a *synchronization* pulse is sent from the video adapter to the monitor. There is a separate pulse for horizontal synchronization and vertical synchronization. In most current monitors, synchronization signals are edge triggered TTL (transistor-transistor logic) signals. *Polarity* refers to the edge that triggers the synchronization. A falling trigger (marked "-" or "positive/negative") indicates that synchronization takes place at the high-to-low transition of the sync signal. A leading trigger (marked "+" or "negative/positive") indicates that synchronization takes place on the low-to-high transition of the sync signal.

Putting the Basics to Work. It is a popular misconception that monitors "make" an image. That's not the case at all. Actually, it is the *video board* that generates the image. A monitor is little more than a "converter" or "interpreter" that takes the color signals produced by your video adapter and places the proper colors in the corresponding locations on a CRT to produce a visible picture. In order to accomplish that feat, a monitor must perform several distinct functions:

(1) produce power and high voltage

(2) generate and focus electron beams

(3) modulate the electron beam strength based on color signals from the video board, and

(4) sweep the electron beams across the CRT in a synchronized fashion.

The block diagram in Fig. 4 shows you what's needed for a monitor to work.

The Color CRT. It is the design and construction of the CRT itself (Fig. 5) that really makes color monitors possible. Low voltage from the power supply heats a cathode in the CRT's neck. That causes electrons to "boil" off the cathode and

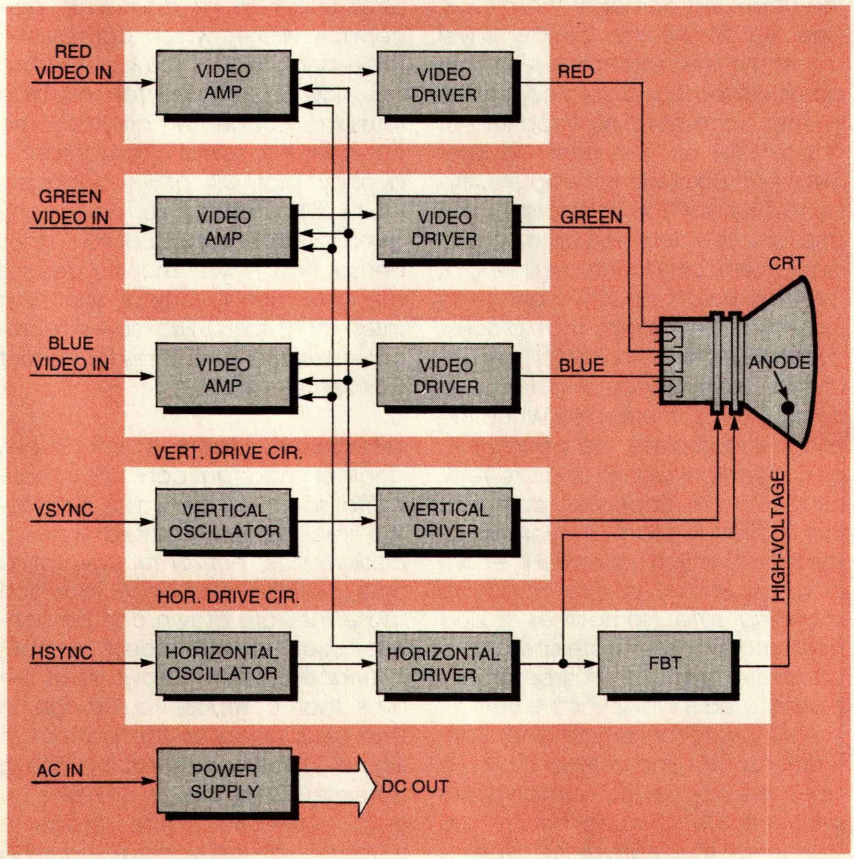


Fig. 4. This simplified block diagram shows the circuitry that is needed by a typical color computer monitor.

MONITOR MANUFACTURERS

Acer America Corp.
2641 Orchard Parkway
San Jose, CA 95134
Tel: 800-733-2237

Amdek
Division of Wyse
3471 N. First Street
San Jose, CA 95134
Tel: 408-922-5700

AST Research
16215 Alton Parkway
Irvine, CA 92713
Tel: 714-727-4141

ATI Technologies
3761 Victoria Park Avenue
Scarborough, Ontario, Canada, M1W 3S2
Tel: 416-756-0718

CTX International, Inc.
20530 Earlgate Street
Walnut, CA 91789
Tel: 714-595-6146

Diamond Computer Systems
470 Lakeside Drive
Sunnyvale, CA 94086
Tel: 408-736-2000

Eizo NanaoTechnologies, Inc.
5710 Warland Dr.
Cypress, CA 90630
Tel: 800-800-5202

Epson America, Inc.
20770 Madrona Avenue,
Torrance, CA 90503
Tel: 800-922-8911

Everex Systems
48431 Milmont Drive
Fremont, CA 94538
Tel: 800-821-0806

GoldStar Technologies
3003 N. First Street
San Jose, CA 95134-2004
Tel: 800-777-1194

Hewlett-Packard Company
California Personal Computer Division
974 E. Arques Avenue
P.O. Box 3486
Sunnyvale, CA 94086
Tel: 800-752-0900

Idek/Iiyama North America, Inc.
650 Louis Drive, #120
Warminster, PA 18974
Tel: 215-957-6543

Leading Technology
10430 S.W. Fifth Street
Beaverton, OR 97005
Tel: 503-646-3424

MAG Innovision, Inc.
4392 Corporate Center Drive
Los Alamitos, CA 90720
Tel: 800-827-3998

Magnavox
Philips Consumer Electronics
One Phillips Drive
Knoxville, TN 37914
Tel: 423-521-4316

Mitac USA, Inc.
42001 Christy St.
Freemont, CA 94538
Tel: 510-656-3333

Mitsubishi Electronics America, Inc.
Information Systems Division
5757 Plaza Drive
P.O. Box 6007
Cypress, CA 90630
Tel: 800-843-2515

NEC Technologies, Inc.
1255 Michael Drive,
Wood Dale, IL 60191
Tel: 800-388-8888

Packard Bell Electronics
9425 Canoga Avenue
Chatsworth, CA 91311
Tel: 818-773-4400

Panasonic
2 Panasonic Way
Secaucus, NJ 07094
Tel: 800-346-4768

Princeton Graphic Systems
2801 S. Yale St. #110
Santa Anna, CA 92704
Tel: 800-747-6249

Relisys
320 S. Milpitas Boulevard
Milpitas, CA 95035
Tel: 408-945-9000

Sampo Corp. of America
5550 Peachtree Industrial Boulevard
Norcross, GA 30071
Tel: 404-449-6220

Samsung Electronics America
105 Challanger Rd.
Ridgefield Park, NJ 07660
Tel: 201-229-4132

Seiko Instruments USA, Inc.
Color Graphics Group
1130 Ringwood Court
San Jose, CA 95131
Tel: 800-888-0817

Sony Computer Peripheral Products Co.
655 River Oaks Parkway,
San Jose, CA 95134
Tel: 800-352-7669

Tatung Co. of America, Inc.
2850 El Presidio Street
Long Beach, CA 90810
Tel: 800-829-2850

Toshiba America Consumer Products, Inc.
1010 Johnson Drive
Buffalo Grove, IL 60089-6900
Tel: 708-541-9400

ViewSonic
12130 Mora Drive
Santa Fe Springs, CA 90670
Tel: 800-888-8583

those are accelerated toward the phosphor-coated front screen by a high positive potential. Color CRTs use three cathodes and video control grids—one for each of the three primary colors. The *control grid* regulates the overall brightness of the electron beams, the *screen grid* begins accelerating the electron beams toward the front face of the CRT, and the *focus grid* narrows the beams. Once the electron beams are focused, vertical and horizontal deflection coils (or deflection yokes) located around the CRT neck will apply magnetic force to direct the beams across the screen.

You will also notice a *shadow mask* in the color CRT. A shadow mask is a thin plate of metal that contains thousands of microscopic perforations—one perforation for each screen pixel. The mask is placed in very close proximity to the phosphor face. Rather than a single homogeneous layer of phosphor as with a monochrome CRT, the color CRT uses phosphor *triads* as shown in Figure 1. Red, green, and blue phosphor dots are arranged in sets such that the red, green, and blue electron beams will strike the corresponding phosphor. Of course, the electron beams are invisible (and color is determined by the phosphor itself), but each electron beam is intended to excite only one color phosphor. In actual operation, the color dots are so close together that each triad appears as a single point (or pixel) to the human eye.

Color CRTs must also be very precise in how the three electron beams are directed around the screen. Since there are three phosphors, it is critical that each electron beam strike only its corresponding phosphor color, not adjoining phosphors. How well that task is accomplished is known as *color purity*. A *purity magnet* added to the CRT neck helps to adjust fine beam positioning. By using a shadow mask, the electron beams are only allowed to reach the phosphors where there are

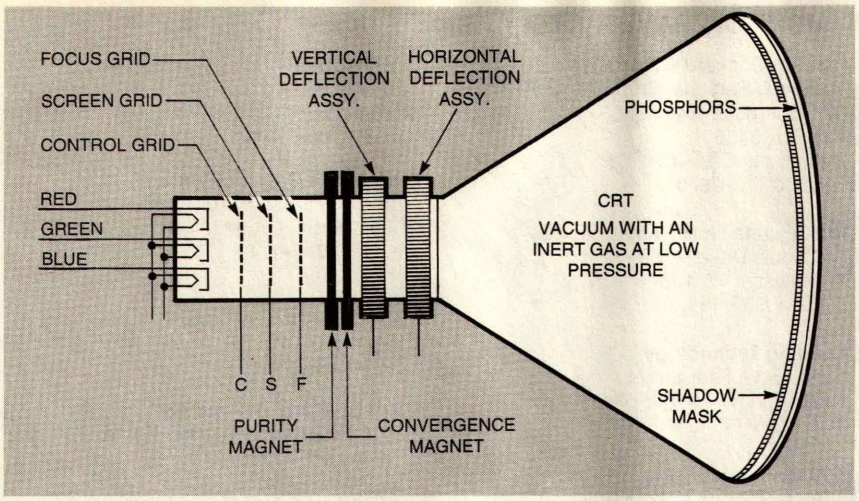


Fig. 5. The monitor's image is displayed on a cathode-ray tube, or CRT. A diagram of a typical CRT is shown here.

holes in the mask. Also realize that each of the three electron beams must converge at each hole in the shadow mask. A *convergence magnet* added to the CRT neck adjusts beam convergence in the display center (known as *static convergence*), while a convergence coil driven by the raster circuitry handles beam convergence at the edges of the display (known as *dynamic convergence*). It is that delicate balance of purity and convergence adjustments, as well as the presence of a shadow mask, that give today's color monitors such rich, precise color.

Video-Drive Circuits. A *video drive circuit* is used to regulate the strength of an electron beam by adjusting the signal strength on the corresponding video control grid in the CRT. The video drive circuit must convert a small video signal from the PC's video adapter (usually no more than 0.7 volts peak-to-peak) into a signal large enough to drive the CRT (typically between 30 to 50 volts). For color monitors with three analog video lines, three separate video drive circuits are required.

The initial video amplifier of each stage (often referred to as a *pre-amp*) is a linear, high-gain amplifier that translates the low-level analog color signal into a clear, solid analog level of several volts (usually about 3 volts). A common *contrast control*, which affects each of the three video amplifiers simultaneously, is typically added. Unfortunately, the amplified analog signal is not enough to drive the CRT's video control grid. Additional amplification is required, so a secondary amplifier stage is added. Some monitor designs use a three-stage amplifier circuit for each color; a high-gain *pre-amp* for lots of amplification at little power, a second *amplifier* that provides less amplification but more power to the signal, and a *driver* that offers almost no amplification but provides enough signal power to drive the CRT.

Vertical-Drive Circuit. The *vertical-drive circuit* is used to operate the vertical-deflection yoke, and is part of the color monitor's overall raster circuitry. The heart of the circut is a *vertical-sweep oscillator*, which is little more than a free-running oscillator set to run at either 60, 70, 72 Hz (or more—depending on the design of the particular monitor). Older color monitors typically used transistor-based oscillators, but virtually all current color monitors use an integrated-circuit oscillator, since ICs provide a very linear and precise signal. The vertical oscillator, is forced to fire when a vertical-synchronization trigger pulse is received from the video-adapter board. When the oscillator is triggered, it produces a sawtooth wave. The start of the sawtooth wave corresponds to the top of the screen, while the end of the sawtooth wave corresponds to the bottom of the screen. When the sawtooth cycle is complete, there is a blank period for blanking and retrace. One vertical sweep will be accomplished in less than 1/60th of a second (or 1/70th or 1/72nd of a second depending on the monitor).

However, the sawtooth signal generated by the vertical-oscillator circuit does not have enough power to drive the vertical-deflection yoke directly. The vertical deflection sawtooth signal is amplified by a *vertical-output driver* circuit (or vertical amplifier). The vertical amplifier provides the significant current needed to induce a strong magnetic field in the vertical-deflection yoke. The amount of power needed to operate the deflection yoke demands the use of a high-power transistor arrangement, but many current monitor designs are using high-power amplifier ICs instead of discrete transistors.

There are a number of adjustments in the vertical-drive circuit that you should be familiar with. The *vertical linearity* optimizes the shape of the sawtooth waveform. Ideally, the wave's upward ramp should be perfectly straight (or linear). In actual practice, however, the slope of the line may vary a bit from start to finish. That translates to the display. Since the ramp defines the spacing between individual lines, any variation in the ramp "slope" will effect the spacing between horizontal lines. Typically, you need not adjust vertical linearity unless you replace a component in the oscillator circuit. The *vertical-size* control adjusts the slope of the ramp signal, which effects the final amplitude of the sawtooth. That effectively compresses or expands the screen image in the vertical direction. By applying a DC offset to the vertical-deflection signal, the raster can be centered in the display with a *vertical-centering* control.

Horizontal-Drive Circuit. The *horizontal-drive circuit* is the second part of the color monitor's raster circuit, and it is designed to operate the horizontal-deflection yoke. The heart of this circut is a *horizontal oscillator*, which is little more than a free-running oscillator set to run at

a frequency between 15 kHz and 48 kHz (or higher). A CGA monitor will typically use a horizontal sweep frequency of about 15.75 kHz. The actual oscillator may be based on a transistor, but is usually designed around an integrated circuit which is more stable at the higher frequencies that are needed. When a horizontal-synchronization trigger pulse is received from the video-adapter board, the oscillator is forced to fire. When the oscillator is triggered, it produces a squarewave. The start of the squarewave corresponds to the left side of the screen. When the cycle is complete, there is a blank period for blanking and retrace. At an operating frequency of 31.5 kHz, one horizontal sweep will be accomplished in about 31.7 μS.

As with vertical-oscillator circuits, the signals generated by the horizontal oscillator do not have enough power to drive the horizontal-deflection yoke directly. The horizontal-deflection pulse signal is amplified by a *horizontal-output driver* circuit (or horizontal amplifier), which provides the significant current needed to induce strong magnetic fields in the horizontal-deflection yoke. The amount of power needed dictates the use of a high-power transistor arrangement. Transistors are still popular today as horizontal output drivers.

There are a number of adjustments in the horizontal drive circuit that you should be familiar with. The *horizontal linearity* optimizes the shape of the horizontal sweep. Ideally, the left-to-right sweep rate should be perfectly even, but the actual sweep rate may vary a bit from start to finish. That variation will affect the spacing between pixels in a line. Typically, you need not adjust horizontal linearity unless you replace a component in the oscillator circuit. The *horizontal-size* control adjusts the signal magnitude, which affects the amount of sweep applied to the electron beam. That effectively compresses or expands the screen image in the left-to-right orientation. A third control allows the adjustment of *horizontal centering* by introducing a slight delay between the time an Hsync (horizontal-synchronization) pulse is received and the time a horizontal pulse is generated. By default, there is always some delay needed to produce a centered display image. Reducing the delay moves the screen image to the left, while increasing the delay moves the screen image to the right. Centering and size controls are most useful for optimizing the image size and position for a particular video mode, and should not need to be readjusted unless the video mode changes.

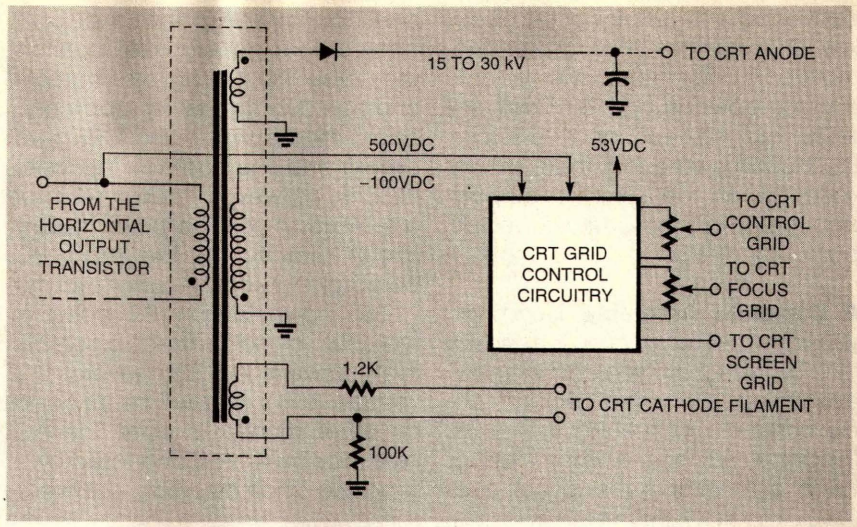


Fig. 6. The high voltages required by the CRT are generated by the monitor's flyback transformer.

High-Voltage Circuit. The *high-voltage system* is actually part of the horizontal drive circuit. We discuss it separately because of its importance in computer monitors. A monitor's power supply generates relatively low voltages (usually not much higher than 140 volts). That means that the high positive potential needed to excite the CRT's anode is *not* developed in the power supply. Instead, the 15 to 30 kV needed to power a CRT anode is generated from the horizontal output. The amplified, high-frequency pulse signal generated by the horizontal-output driver circuit is provided to the primary winding of a device known as the *flyback transformer* (or FBT). It is the FBT that produces the high-voltage.

You can see the diagram for a typical FBT in Fig. 6. Three secondary windings are shown. The lower winding is a simple step-down winding that provides a low AC voltage (typically about 6.2 to 15 VAC depending on the particular CRT) that heats the color CRT's three cathodes. The middle winding provides about 100 volts to the CRT control circuit. A 500-volt signal from the horizontal output and a 53-volt input from the monitor's power supply also power the CRT control circuit (the actual voltage levels will vary slightly from monitor to monitor). Adjustable control-grid voltage (brightness), the adjustable focus-grid voltage (focus), and the fixed screen-grid voltage are all generated by the FBT circuit.

The FBT's top winding is the high-voltage winding that steps up the horizontal signal to the required 15- to 30-kV level (the actual voltage level will depend on the particular monitor—larger CRTs require greater voltages to operate). Notice that a high-voltage diode is placed in series with the high-voltage winding to *rectify* the high AC level to a DC level. The 500 pF of effective capacitance found in the CRT assembly acts to *filter* (or smooth) the high-voltage into a useful form. In effect, that arrangement forms its own power supply. The high positive voltage applied to the CRT anode causes the electron beams to stream toward the phosphor-coated face.

Power Supply. The operation of every color monitor relies on the proper performance of a power supply, where commercial AC is

converted into a series of relatively low DC voltages that power the monitor. A color monitor will typically use a power supply that delivers +135, +87, +20, +12, and +6.3 volts DC, but be aware that there will be variations in the supply's outputs depending on the design of each particular monitor.

A Complete Assembly. Now that you know the major circuits needed for a color monitor, you can see how everything fits together in the exploded diagram of Fig. 7. The first thing you may notice when looking inside a monitor is the layout and position of the printed circuit boards. As a general rule, monitors use three PC board assemblies—one board for the power supply, one board for the video and CRT drive circuits, and one board for the raster circuits. However, many monitor assemblies place the power supply circuit directly on the main PC board along with the raster circuits.

The *power supply PC board* is typically a hand-sized assembly that converts AC into several DC voltage levels that will be needed by other monitor circuits. The AC itself may be filtered and fused by a separate small assembly. If there is no stand-alone power-supply board in your particular monitor, the supply is probably designed into the main monitor board. The only voltage that is *not* produced in the power supply is the high-voltage source. The power-supply board is mounted vertically to a metal frame. The metal frame not only provides a rigid mounting platform, but it serves as a chassis common, and helps to contain RF signals generated by the monitor.

The *CRT-drive PC board* attaches directly to the CRT pins through a circular connector at the neck. Control (brightness), screen, and

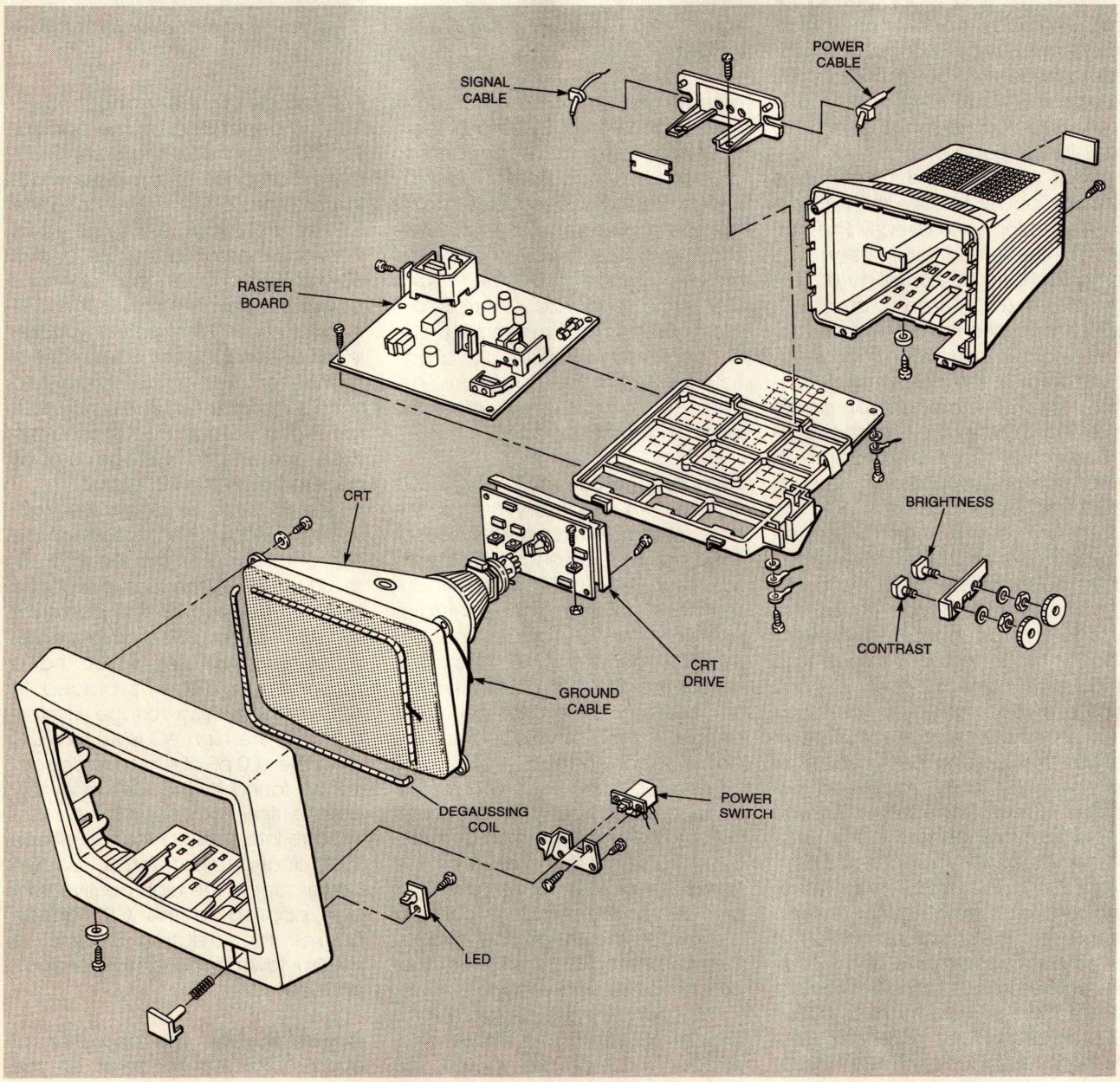


Fig. 7. Inside a typical monitor. This exploded view shows the CRT, the main or raster board, the CRT-drive board, and more. (Illustration Courtesy of Tandy Corporation).

focus grid voltages are applied to the CRT through that board. The CRT drive board also usually contains the RGB video amplifiers and drivers. Since more video-drive circuitry is needed for a color monitor than a monochrome monitor, the CRT-drive PC board for a color monitor is usually much larger than that of a monochrome monitor. Once the monitor is unplugged and discharged, make sure that this board is attached evenly and securely to the CRT.

The main *monitor PC board* (often called the *raster board*) contains the vertical-raster, horizontal-raster, and high-voltage circuits that drive the CRT and direct the electron beam(s) around the screen. Depending on the design of your particular monitor, the main monitor board may contain part or all of the power supply circuit as well. Just about all monitors mount the main PC board to the metal frame horizontally below the CRT neck. That assembly can be difficult to remove, since it is obstructed by the CRT neck and yoke, as well as by the interconnecting wiring that connects to the power supply, front panel controls, and flyback transformer.

There are some other assemblies in Fig. 7 that you should be familiar with. Note the thick wire surrounding the CRT screen. That is known as a *degaussing coil*, and is required on all color monitors. Since magnetism influences the path of the electron beams, and all three electron beams must be aligned precisely to achieve proper color, any stray magnetic influence will upset the display's color purity. It is not uncommon for small areas of the metal shadow mask to become magnetized. When this occurs, the color in those magnetized areas will be distorted. The degaussing coil plugs into the power-supply circuit. When the monitor is first turned on, a temporary AC voltage in the coil creates a strong alternating magnetic field that acts to clear any magnetized regions in the shadow mask. After a moment, AC is cut off in the coil, and the CRT will operate normally.

The *horizontal-output transistor* can be mounted on a separate heat sink or mounted to a heat sink on the main monitor PC board. The horizontal-output transistor is a key component, since it not only drives the horizontal deflection yoke but the flyback transformer as well. You may also notice the *high-voltage anode*, which originates at the flyback transformer and is little more than a metal prong covered by a large red plastic insulator. That anode must be inserted fully in the CRT. **Never touch the anode wire or connector (even when the monitor is turned off)**. That conductor is carrying 15 kV or higher, so a VERY dangerous shock hazard exists. The monitor must be UNPLUGGED and the CRT must be safely discharged before working with the high-voltage anode.

Finally, you should take note of any metal shrouds or coverings that are included in a monitor. Metal shielding serves two very important purposes. First, the oscillators and amplifiers in a computer monitor produce radio-frequency (RF) signals that have the potential to interfere with radio and TV reception. The presence of metal shields or screens helps to attenuate any such interference, so always make it a point to replace shields securely before testing or operating the monitor. Second, large CRTs (larger than 17 inches) use very high voltages (25 kV or more) at the anode. With such high potentials, X-radiation becomes a serious concern. CRTs with lower anode voltages can usually contain X-rays with lead in the CRT glass. Metal shields are added to the larger CRTs in order to stop X-rays from escaping the monitor enclosure. When X-ray shielding is removed, it is vital that it be replaced before the monitor is tested and returned to service. X-ray shields will usually be clearly marked when you remove the monitor's rear cover.

Conclusion. Computer users are often so obsessed with clock speed, system RAM, and hard-drive size, they overlook the importance of their monitor. But the monitor is a very vital part of the PC as it is what converts video data into a visible image. This article explains the important ideas behind monitor operation, shows you the major parts involved, and illustrates a typical monitor assembly.

The author welcomes comments and questions about this article. He can be reached via Fax at 508-829-6819, by BBS at 508-829-6706, on CompuServe at 73562,3205, or via e-mail at sbigelow@cerfnet.com. You can also visit his Dynamic Learning Systems Web site at www.dispubs.com. Ω

REACT-TIME

(Continued from page 32)

piece of clear plastic to the inside of the lid.

Testing. Install batteries into the holder and turn on the power. The display should read 00. Squeeze both buttons and the 3—2—1 countdown should start. If it doesn't, check the wiring and component placement, measure the supply voltage, and check that the PIC clock is running at 4 MHz by connecting an oscilloscope to the crystal.

Using the React-Time. A lower score means a quicker reaction time. It is possible to score as low as four or five, if you're quick! Most people can score about 10—12 after a dozen tries. Overly intoxicated people will have a very hard (if not impossible) time trying to score below 13. Older individuals might not score lower than 20.

The best way to test someone's reaction time is to first demonstrate how to use the React-Time. The person being tested must cooperate. After the demonstration, they should have about a dozen attempts to lower their score. The score will steadily decrease until there is a point at which they cannot get lower. That score best represents the person's reaction-time performance.

While the unit is intended for entertainment only and should not be used in place of blood-alcohol level testers, the React-Time tester can be used in practical applications. For example, bartenders or party hosts can use the unit to screen those that have had too many. Ω

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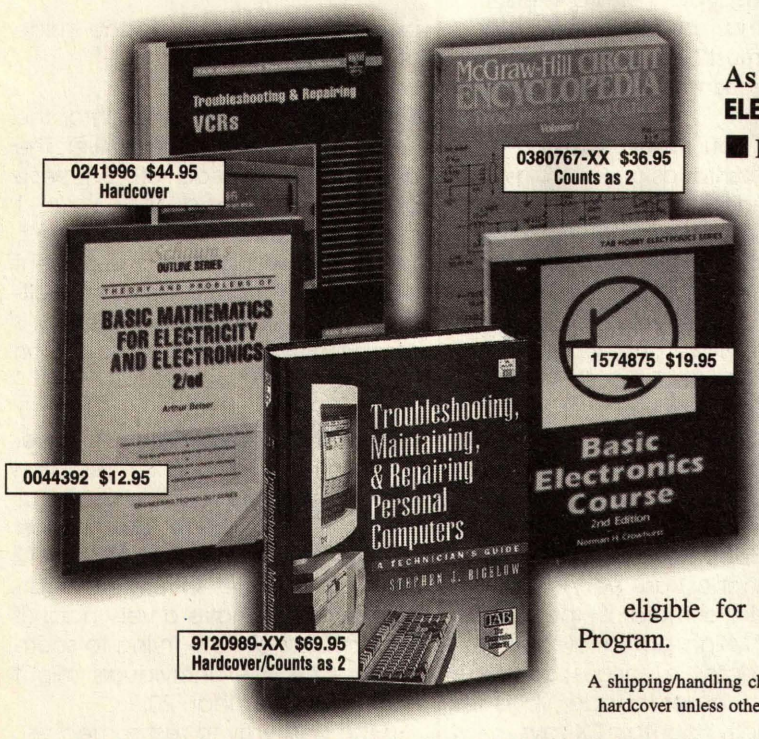

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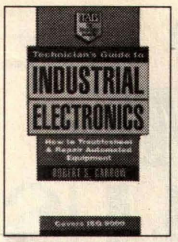

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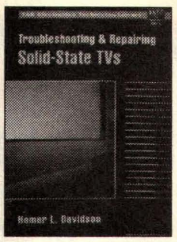

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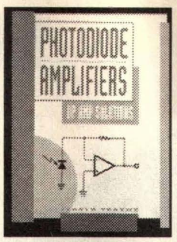

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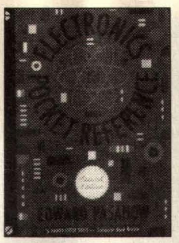

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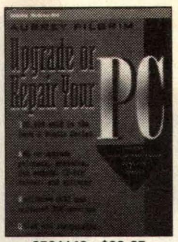

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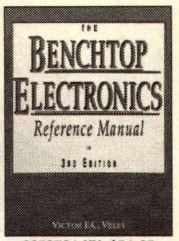

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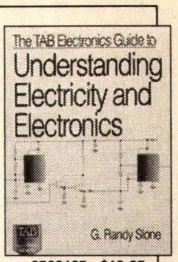

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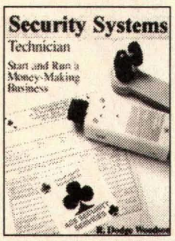

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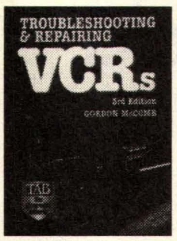

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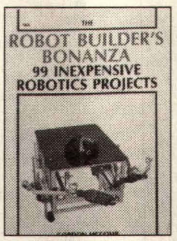

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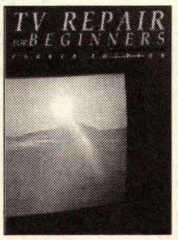

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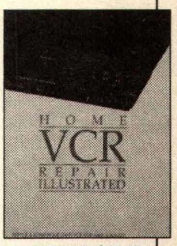

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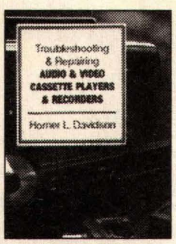

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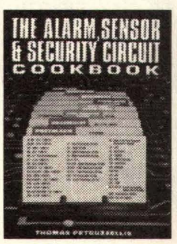

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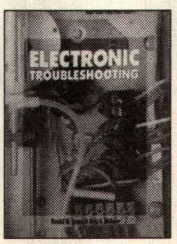

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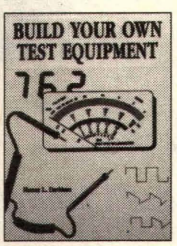

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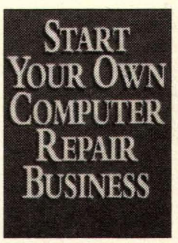

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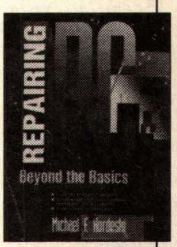

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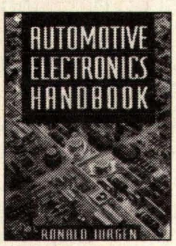

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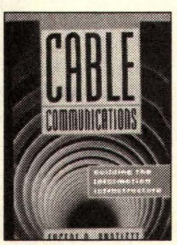

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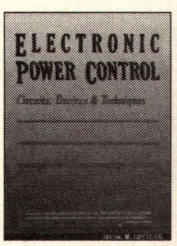

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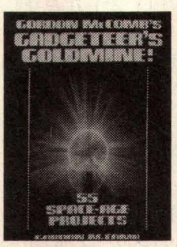

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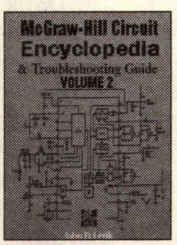

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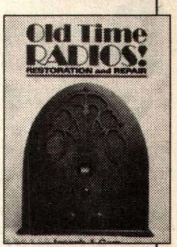

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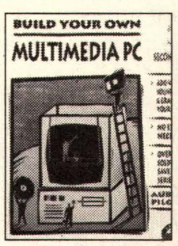

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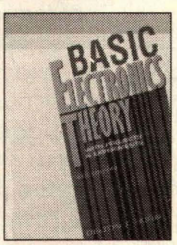

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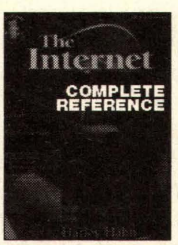

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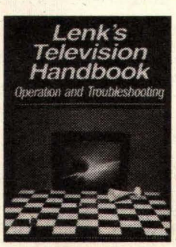

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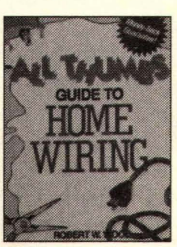
Counts as 2



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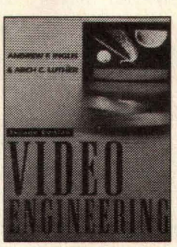
0365946 $22.95



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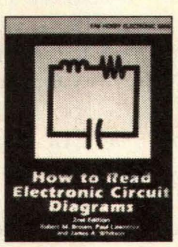
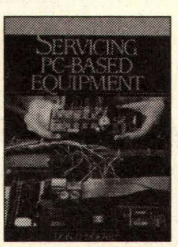
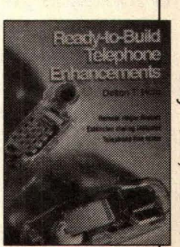


1554637 $16.95



5869349-XX $44.00
Hardcover/Counts as 2



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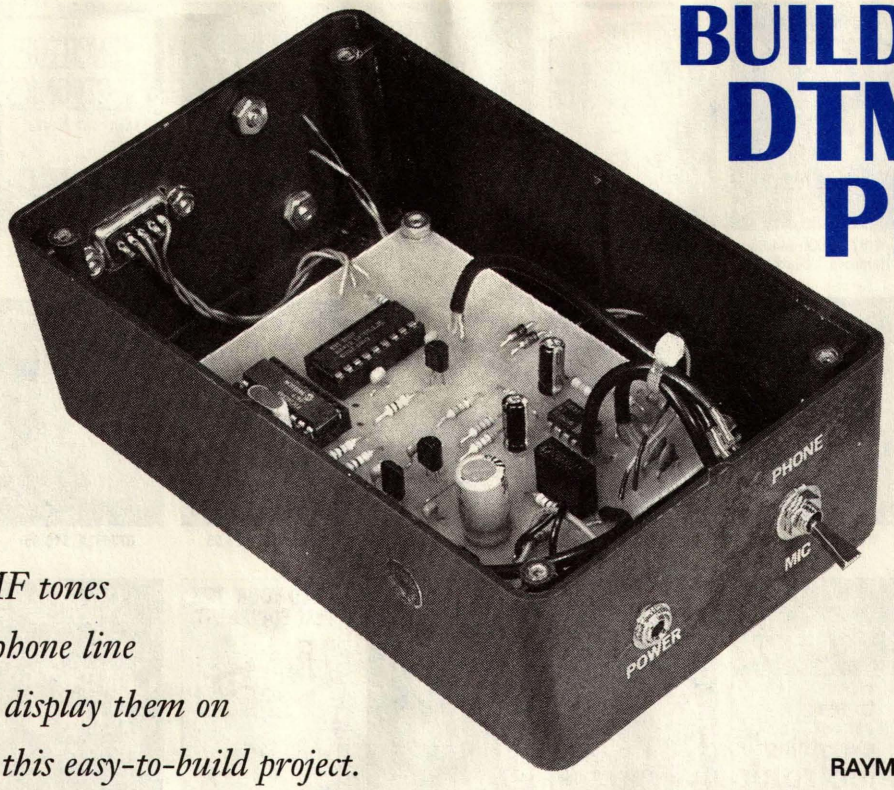
BUILD THE DTMF-PLUS



Decode DTMF tones from the telephone line or radio, and display them on any PC with this easy-to-build project.

RAYMOND C. BUCK, III

Decoding dual-tone modulated-frequency (DTMF) signals continues to be an area of interest for many people. DTMF signals can come from a variety of sources. They are used to control everything from home-automation equipment to amateur-radio repeaters. However, their largest use continues to be in items related to the public-telephone network.

There have been several articles published in the past that have described various ways of accomplishing the task of decoding DTMF signals. The DTMF-Plus universal decoder presented here combines the best features of those previous devices. It will be able to decode any DTMF signal from any source.

How it Works. The heart of the DTMF-Plus decoder is an SSI-202 DTMF-decoder chip. That chip determines which of the 16 possible DTMF tone-pair combinations is being received. The result is sent as an appropriate binary number to a Microchip 16C54 microprocessor. That microprocessor sends the binary information through an RS-232 port to a PC. With appropriate software, the decoded data can be displayed on the PC's screen. There are four different data rates available that should make the unit compatible with any type of PC.

If there is a delay of more than 3 seconds between digits, the cursor on the PC is moved five spaces. If more than 10 seconds elapse between digits, a carriage return and a line feed are sent to the PC. That formatting arrangement makes the screen display more readable. For example, if someone dials a pager number, there is first a wait for the pager service to answer, after which the callback number is entered. The pager access number and the callback number will be displayed in separate columns on the screen. If more than 10 seconds elapse without dialing, the assumption is that there will be no more dialing for that particular call. If additional digits are received later, they will be displayed on a separate line. That should handle most situations.

Circuit Description. There are two possible sources of DTMF tones for the circuit in Fig. 1: MIC1, an audio microphone, or J2, which connects to a standard telephone line. The inputs are individually amplified by IC3, an LM1458 dual op-amp. That chip handles the necessary gain and impedance conversions needed by IC4, an SSI-202 DTMF detector. When the microphone is used as the signal source, some experimentation might be necessary to find the best location for placing MIC1 near a radio speaker. The gain of IC3-a is preset so that normal listening levels are sufficient for the unit to function properly.

The source of DTMF tones is routed by S1 to IC4, where conversion takes place. The binary number appearing on the output pins of IC4 is read by IC5, a 16C54 microprocessor.

The serial output of IC5 drives Q1. In order to make a stream of serial data into a true RS-232 signal, both positive and negative voltages are needed. When Q1 is off, the negative voltage at the TD terminal on the computer's serial port is connected to the RD terminal. Turning on Q1 applies positive voltage to the RD terminal. The circuitry that drives the TD terminal is protected from destruction by R15. That way, a negative-voltage is not needed.

The two jumpers labeled JP1 and JP2 set the speed of the RS-232

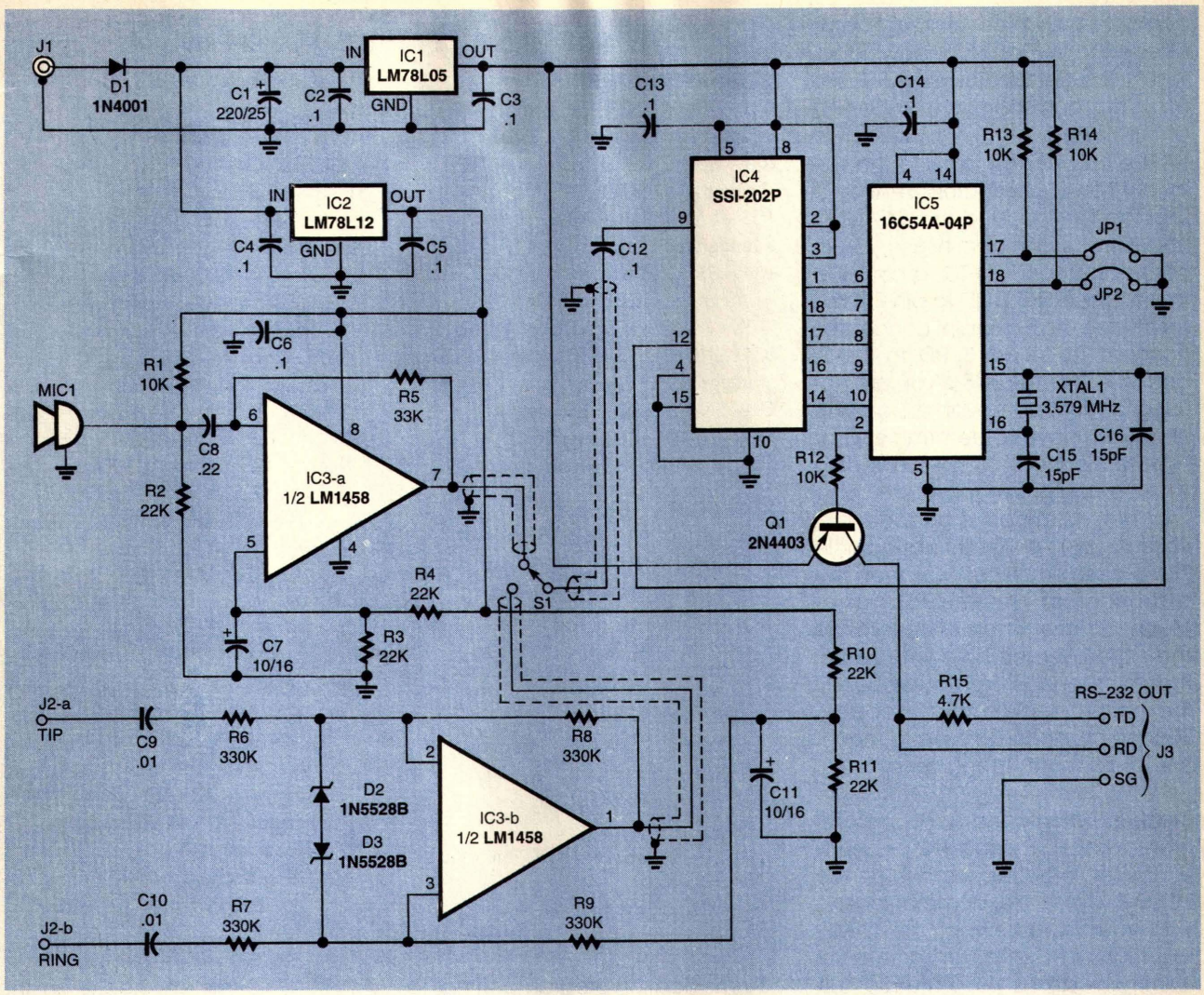


Fig. 1. Thanks to the use of a PIC microcontroller chip, the DTMF-Plus can use a very simple circuit to accomplish some very complicated tasks. The jumper blocks set the data rate to any of four different speeds.

data stream. With no jumpers installed, the speed is 9600 baud. If J1 is installed, the speed is 2400 baud. If J2 is installed, the speed is 1200 baud. If both J1 and J2 are installed, the speed is 300 baud. In all cases, the data stream consists of a start bit, 8 data bits without an additional parity bit, and 1 stop bit.

Power for the unit comes from a 12-volt DC wall-type adapter. The cheapest and smallest one will be fine since current requirements are very low. On-board 5-volt and 12-volt regulators IC1 and IC2 insure that the voltages needed by the individual chips are correct. As most wall-mount supplies do not have very good regulation, additional filtering for both low- and high-frequency ripple is also provided by C1 through C5.

Construction. The DTMF-Plus decoder is simple enough to be built on perfboard. If you wish, you can etch and drill a PC board from the foil pattern supplied. An etched and drilled board is also available from the source given in the Parts List. If you use the provided foil pattern or purchase a board, follow the parts-placement diagram in Fig. 2 for proper component placement. The circuit does not have any critical layout requirements, so either construction method will yield good results.

If you decide to use perfboard, keep the wiring associated with IC3 as short as possible. With either method of construction, the connections to S1 and to the microphone should use shielded audio cable. That shielding will prevent any stray hum from interfering with the DTMF tones. It is important to connect only one end of the wire shields to ground, not both. If that does happen, a ground loop will be created. Instead of minimizing noise pickup, that situation will cause the shields to act like an antenna, resulting in more noise than if unshielded wire were used.

Using sockets for IC4 and IC5 is a good idea in case one of those components has to be changed in the future. You might also use a socket for IC3, especially if you are using perfboard construction.

It is necessary for a special program to be burned into IC5 before installing it into the PC board. A preprogrammed chip is available from the source shown in the Parts List. If you want to program your own

component, the source code needed is available for downloading at the **Electronics Now** FTP site (ftp://ftp. gernsback.com/pub/EN/dtmfplus.exe).

The only connections to the serial port on a computer are the TD line, the RD line, and the SIG GND line. If the serial port has a 25-pin connector, connect TD to pin 2, RD to pin 3, and SIG GND to pin 7. If the serial port has a 9-pin connector, connect TD to pin 3, RD to pin 2, and SIG GND to pin 5. If you are not using an IBM-compatible computer, you will have to determine what pins to connect to by consulting your computer's manuals.

When installing the decoder in a case, it would be best to drill a hole in the case slightly smaller than the diameter of the microphone. Mounting the microphone inside the case over the hole will protect the microphone from damage if the unit is accidentally dropped. Silicone glue can be used to mount the microphone to the case.

Testing. When construction is completed, install JP1 and JP2 as needed to set the speed at which the DTMF-Plus will be communicating with your PC. Connect the DTMF-Plus to your PC and start a terminal communications program. Set up the program for the serial port to which the DTMF-Plus is connected.

The easiest way to test the unit is to connect it to a telephone line. Remove the cover from a telephone wall jack. Depending on how old the wiring is, there will be two different color code schemes in use. In the case of older wiring, the colors are green and red. With newer wiring, the colors are white wire with a blue stripe, and blue wire with a white stripe. Connect the DTMF-Plus to those wires. If you have two telephone lines in the house, line 2 might be on the white with orange stripe and orange with white stripe wires. In the case of older wiring, line 2 should be on the black and yellow wires. Polarity of the connections does not matter.

When the unit is turned on, the computer screen should display: "Touch-tone decoder is now active." If garbage characters appear on the screen, check the communication program settings to make sure they are set properly. If there is no characters at all, check the wiring between the unit and the PC. Also, check the unit to make sure there are no wiring errors. If you see the sign-on message, check to make sure that S1 is in the telephone position. Pick up a telephone and dial three or four digits. Pause for 4 seconds and dial a few more digits. The two groups of numbers should appear in two separate columns. Ten seconds after the last digit is dialed, the cursor should drop down to the beginning of the next line.

Once the telephone connection is working properly, the microphone is tested next. Turn on a shortwave or amateur receiver and tune to a signal where DTMF signals can be heard. Turn the receiver volume level up to a comfortable level and place the DTMF-Plus about 6 inches from the speaker. Set S1 to the microphone position. As DTMF signals are heard on the receiver, the corresponding numbers should be displayed on the PC screen. If a suitable receiver is not available, you could also use a speakerphone to test the microphone. Place the unit in front of the speakerphone and turn the speakerphone on. Go to another telephone, pick it up, and dial several digits. The digits should be heard over the speakerphone. The DTMF-Plus should decode them and send them to the PC. Note, however, that some speakerphones limit and clip loud signals, which could result in distortion of the tones. If that happens, the unit will not decode them, and this technique will not work.

If everything is working well, the unit is ready to be put to use. You may leave it connected permanently to the telephone line if you wish. It will not interfere with normal telephone operation and the incoming ring voltage from the

PARTS LIST FOR THE DTMF-PLUS

SEMICONDUCTORS

IC1—78L05 voltage regulator, integrated circuit
IC2—78L12 voltage regulator, integrated circuit
IC3—LM1458 dual op-amp, integrated circuit
IC4—SSI-202P DTMF decoder, integrated circuit (Silicon Systems SSI75T204-IP or similar)
IC5—PIC16C54A-04P microprocessor, integrated circuit
Q1—2N4403 PNP transistor
D1—1N4001 silicon diode
D2, D3—1N5528B Zener diode

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1, R12, R13, R14—10,000 ohm
R2–R4, R10, R11—22,000-ohm
R5—33,000-ohm
R6–R9—330,000-ohm
R15—4,700-ohm

CAPACITORS

C1—220-µF, 25WVDC, aluminum electrolytic
C2–C6, C12–C14—0.1-µF, ceramic disc
C7, C11—10-µF, 16WVDC, aluminum electrolytic
C8—0.22-µF, ceramic disc
C9, C10—0.01-µF, ceramic disc
C15, C16—15-pF, ceramic disc

ADDITIONAL PARTS AND MATERIALS

J1—Wall-adapter compatible power-input jack
J2—Modular telephone jack
J3—DB-9 or DB-25 RS-232 connector
JP1, JP2—2-position header pin
MIC1—Electret-condenser microphone cartridge
S1—Single-pole, double-throw toggle switch
XTAL1—3.579-Mhz crystal jumper blocks, 12-volt DC wall adapter, case, hardware, etc.

Note: The following items are available from ATC Electronics, PO Box 14091, Scottsdale, AZ 85260-4091: Preprogrammed PIC16C54 microcontroller, $10.00; Printed circuit board, $6.50; IC4 (SSI-202P), $2.25; Complete kit of all parts, less case and RS-232 connector, $32.50; Data-logging program, $7.50. Please add $4.00 for shipping and handling on all component orders—data-logging program price includes shipping. AZ residents must add appropriate sales tax. IC4 is also available from B. G. Micro, Inc., PO Box 280298, Dallas, TX 75228, Tel: (800) 276-2206.

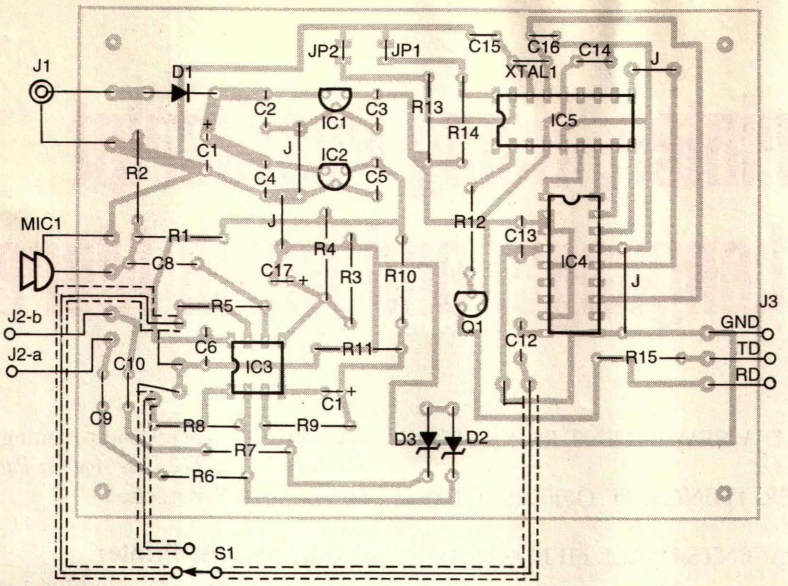
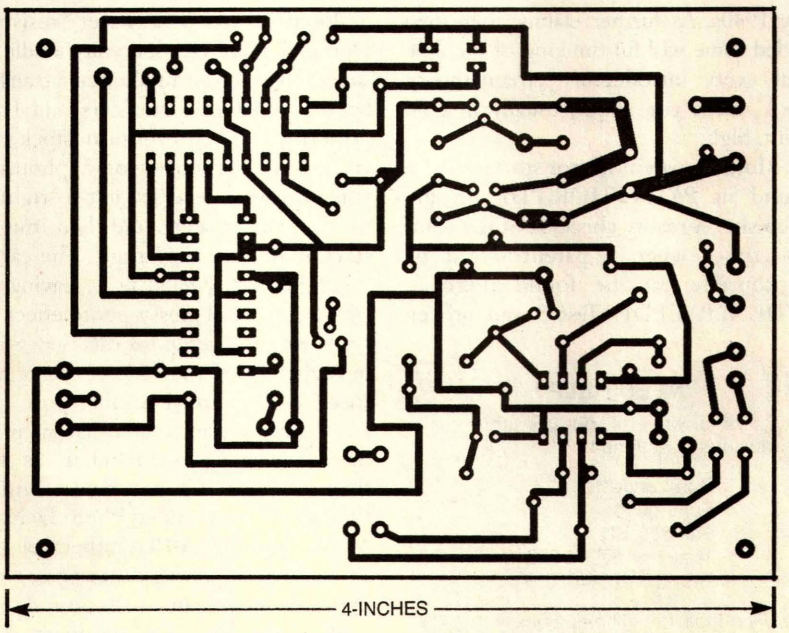


Fig. 2. Use this parts-placement diagram to locate the parts of the DTMF-Plus if you use the foil pattern. Shielded cable should be used to connect S1. The shield should be connected to the ground holes in the PC board only—do not connect them together at the switch.

telephone system will not have any adverse affect on the unit.

Using the DTMF-Plus. Data from the DTMF-Plus can be displayed on a PC using any available communications program. An optional data-logging program is also available from the source given in the Parts List to permanently store any information that is decoded. That program lets you store any data that is decoded for viewing at a more convenient time. For example, you can leave the DTMF-Plus connected to a telephone line and a PC. Each time a number is dialed, it will be stored in the computer for later viewing. Each time the DTMF-Plus sends a carriage return/line feed combination, the line of digits is stored as a call record in a database. Records can be deleted from the database on an individual basis or all records can be deleted at once. That DOS-based program runs on any IBM-compatible computer.

As you explore the abilities of the DTMF-Plus, you'll find new ways to use the unit. One use is as a tester for telephones, modems, and communication programs. The only limit is your imagination. Ω



Here's the foil pattern for the DTMF-Plus. A simple circuit and a few jumper wires easily fit the entire project onto a single-sided board.

SMARTBOX

(continued from page 32)

just comes on. Then accelerate slightly and note that LED2 goes out. Allow the vehicle to coast, and note that LED2 comes on again.

You will probably wish to drive several miles at various speeds and through upgrades and downgrades to learn how the setting of R14 suits your vehicle and driving habits. It may be readjusted in accordance with individual taste. Remember, when LED2 is on, the compressor is enabled when the air-conditioning system calls for cooling.

Once the calibration is completed to your satisfaction, install the Smartbox in the vehicle where the driver can operate S1 and view the LEDs.

When the vehicle is parked in full sun on a hot day, you may wish to use the override switch to obtain maximum cooling power until the interior is cool. That allows the system to operate normally without the fuel-saving feature. Once the interior of the vehicle is comfortable, switch back to automatic control for improved fuel economy and vehicle performance. Ω

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BY DON LANCASTER

A Great New Printer, Using PostScript as a Computer Language, and Much More

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This new service certainly is fast, convenient, and scads of fun to play with. Text and complete figures are included, as are "forward-looking" cross references. The site is not yet in Adobe Acrobat, so the figures remain somewhat grubby looking. And I feel their search engine seems to be a tad on the weak side.

But note that not one patent in 200 ever shows any net positive cash flow, and less than one patent in 1000 is ever "new" enough or "non-obvious" enough that it cannot get busted with a thorough enough search for prior art in obscure enough places. Thus, any patent repository might overwhelmingly end up providing a mind-numbing stash of incompetent failures and total losers. An amazing number of patents just plain do not work. Your effort is infinitely better spent studying the trade journals and all of the web sites where the winners consistently appear.

For instance, I was two for two on my first visit here. I looked into two patents and now have a pair of superb new candidates for my patent horror-story collection. I first searched on "AC phase control" to find out where it would lead me. The first patent, from 1992, looked vaguely familiar. Sure enough, I had published the exact same waveforms back on page 30 of the September 1969 issue of **Popular Electronics**. While studiously ignoring obvious high-profile, public-domain prior art, they did, of course, manage to make their design far more complex and way more expensive than necessary.

The second patent was more recent, and even sadder. They started with a 1938 construction project from *Radio News* that talked about what was then referred to as a Thyratron half-wave proportional AC power control—a fine subject that later became a mainstay chapter in most industrial-electronics books of the 1940s. As further claims, they then added some wishful thinking of the type that every introductory circuit-theory book warns you about, usually in bold print. Sigh.

More on patent horror stories can be found in PATNTHOR.PDF on my Web site. A reality checklist of the scant few times when a patent might be appropriate can be found there in WHEN2PAT.PDF. Tested and proven alternatives to patents and patenting are provided in my *The Case Against Patents* package from Synergetics.

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A Superb New Printer

I've long been searching for a cost-effective way to do high quality, full-color covers for my book-on-demand publishing. There is now this utterly amazing new MD-2010 printer from Alps that fills the bill beautifully, and at a street price as low as $390.

The unit is a letter- to legal-size dye sub printer. Their micro-dry inks arrive on ribbons, usually in photo-realistic black, cyan, magenta, and yellow, but optionally in metallic-foil gold, silver, and cyan, along with a regular black. Thus, you can easily do Kroy Color and hot-stamp effects with this machine, and the output quality has to be seen to be believed.

Final prints are water resistant. Optional materials let you handle T-shirt, mug, and printed circuit transfers by use of iron-on transfers and back-print stocks. Their back print stock gives you a way to produce glossy "photos"—you auto-print reversed left-to-right on to the transfer sheet, and then iron the stock onto your final page. The carrier sheet then gets peeled away, leaving you with a protected glossy-photo effect.

The typical setup for this is an 8-MB or higher Windows 95 host with a high speed bi-directional parallel port. The fancy and custom, menu-driven, print-driver software is included, as is a stripped down CD version of Adobe PhotoShop they named Photo Deluxe.

The Alps MD2010 is rather well suited to point-of-purchase messages, greeting cards, table tents, badges, and high-quality business cards, and many other kinds of full-color fill-a-local-need spe-

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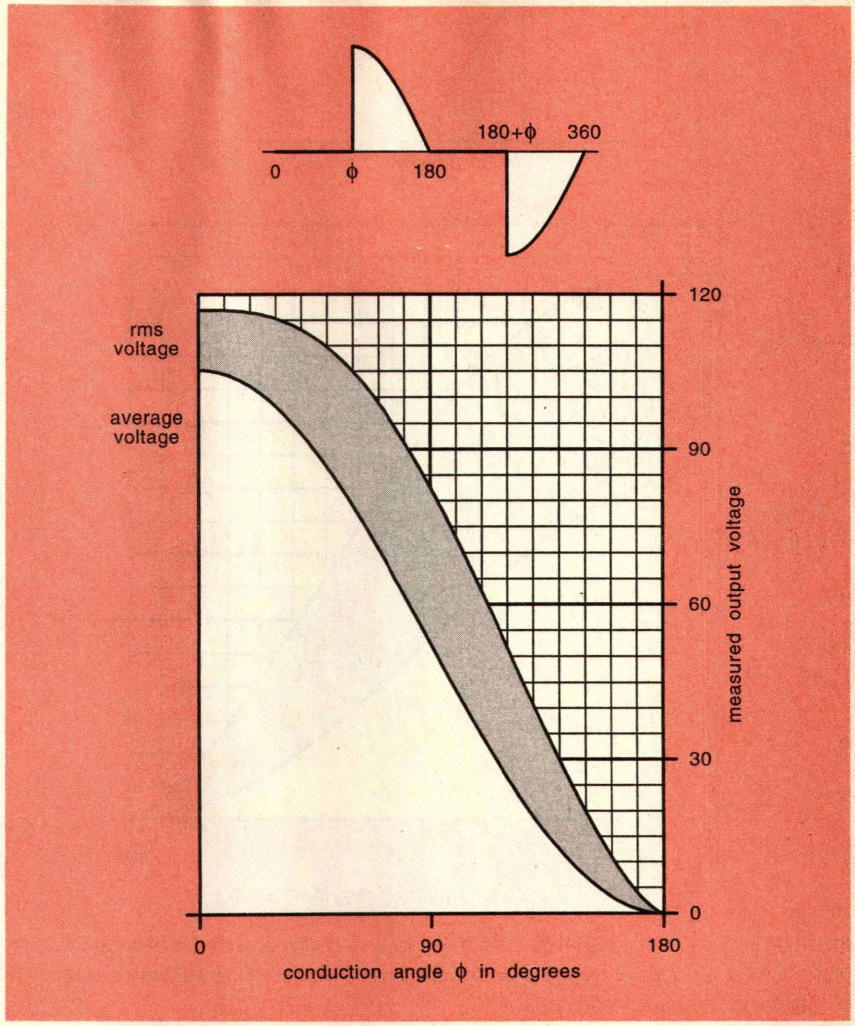

FIG. 1—HOW THE rms AND AVERAGE VOLTAGES for a line-operated, full-wave, Triac phase control vary with the conduction angle.

cialty items.—the kind of stuff you can easily make a buck on. The printer does not directly speak PostScript—at least not yet—but you can easily print PostScript files with the MD-2010 using either "GhostScript" host shareware or by the .PDF format of Adobe Acrobat. Also on this topic, a while back I wrote a COLORIZ2.PS routine that converts older B/W PostScript grays into color tints for web display. Amazingly, that same routine works well on the MD-2010. It invisibly and automatically takes care of the color separations for you!

The printer works on a multiple pass basis, grabbing one ribbon at a time. It sure is fun watching those color separations getting built up into a final print. Because the ribbons are bar coded, any ribbon can go in any slot, but make sure they are right side up and be certain to verify the anti-curling bar is completely to the left when you close the lid.

Alps claims a 14 cents-per-page cost for ribbons. That estimate assumes a "normal" business letter and letterhead with a scant five percent coverage of each color, and is based on a cost of $6 per ribbon. Costs should drop when third-party bulk ribbons and greatly improved prices appear in *Recharger* magazine and similar sources. Anyway, because of denser coverage, any typical book-cover ribbon cost might price out more like 40 cents, or more. Worst case, a full-page and full-color print could exceed several dollars a copy, plus whatever is expended in scrap and testing.

The Alps machine can print up to a 8- by 13.5-inch active area on most any 8.5 by 14 legal sheet. That translates to a book cover that can be over eight-inches high and nearly seven-inches wide, minus bleeds and trims. As an example, my *Active Filter Cookbook* is 5.5-inches wide by 8.5-inches high.

The printer offers a "cardboard" mode that handles papers up to ten mils

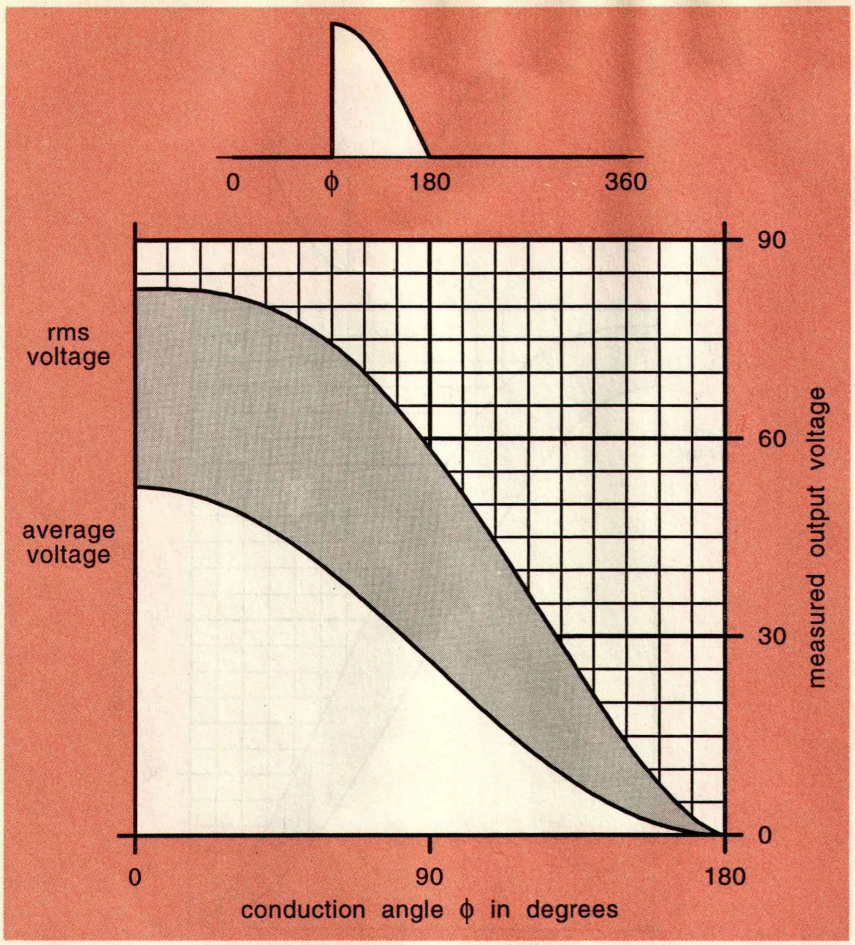

FIG. 2—THE rms AND AVERAGE VOLTAGES for an AC, line-operated, half-wave thyratron phase control. Because it tries to draw direct current from the AC power line, this circuit is obsolete and should no longer be used.

thick. But a better alternative is to print up your cover on a high quality thinner paper and thicken it by using a white self-stick label backing. Giving you a heavy weight and the "duplex-stock" effect of a fully professional cover. Either back-print stock or optional lamination can be used for extra scuff resistance. I personally prefer the low gloss and "lay flat" materials. More on all these binding topics is found in EMERGOP5.PDF.

As you might expect, there is a trade-off for the low cost and high print quality. Here it is in print speed, which is best described as "not quite glacial." For instance, last month's six-page printout (in .PDF form) of my column will print in B/W at 360 copies per hour on my 5SiMx. In color, with host PostScript, the MD2010 just barely manages 3 or so copies per hour. Speed should improve when their internal PostScript upgrade is added. But for now, this printer is clearly not suitable for online network printing, and probably is not your best choice as your first and only printer.

Also note that while the print quality on a light beige is outstanding, I found a very slight patterning on a blue-green tint. Thus, certain light shades often print better than others. I also found their greens wandering off somewhat too far into the blue. For book-on-demand covers, you might want to adjust the colors to suit what the printer does best.

My MUSE112.PDF makes a fairly useful PostScript printer demo. I've also uploaded a new sample test book-on-demand cover as ACTIVCOV.PDF. More on book-on-demand secrets in my *Book-on-Demand Resource Kit* and on the book-on-demand library shelf of www.tinaja.com Incidentally, there's also a version of this printer, the MD-4000, that includes a built-in scanner. The Alps Web site is www.alps.com

PostScript as Language

I have always felt that PostScript is an absolutely outstanding and general-purpose computer language. I use it for nearly all of my design and development work. I have recently used PostScript for everything from my magic sinewave synthesis, to Web site hit analysis, to Smith Chart RF generators, to printed-circuit layouts, to robotics controllers, to stock-market tracking, and more.

Some exciting things have recently happened that make PostScript even more attractive and easier to use. For instance, Adobe Acrobat is now fully Web friendly. Another product, Adobe Access, opens up resources for the disabled. GhostScript shareware gives you one powerful and flexible host-located equivalent to display PostScript. The Videonics folks now have PostScript video apps. And my "Flutterwumper" techniques extend PostScript to cost-effective robotics.

But the really neat new trick is that the Distiller in Adobe Acrobat is also a fast and easy way to do host-based PostScript computing! The Distiller produces printable output files, reads or writes disk data files, or returns recordable data to its log file, making it fast and fun to explore PostScript as language without even needing a PostScript printer.

If you are using Adobe Distiller as a PostScript-as-language computer, note that the results are written to the .LOG file rather than your .PDF file. Because of that, you might often throw away the baby and drink the washwater! More information on PostScript in the "red book" *PostScript Reference Manual* and "blue book" *PostScript Tutorial.* Additional information can also be found on the PostScript library page of www.tinaja.com

Finding rms Currents

A typical example of what you can do when using PostScript as language appears in Listing 1. That listing shows a routine that lets you find the rms and average values for any waveform. It accepts an array of amplitudes as an input. Those values can be mathematically determined or experimentally lab measured.

The example illustrated finds the rms and average voltage values of a full wave Triac phase controller for various firing angles. The data array gets normalized to unity peak amplitude. Every array value first gets squared and summed. Your result then gets divided by the number of samples to find your rms voltage or current.

Although any reasonable number of array values can be used, a hundred to a thousand data points often gives you accurate results, and it does so fairly quickly. You could edit and send the

code to any PostScript printer having two way recordable comm, or route it to GhostScript. But best of all, feed it to Acrobat Distiller 3.0 for convenient and fast host-based computing.

The full-wave results are shown in Fig. 1. As we've seen before, the output rms voltage is not linear with phase angle. That's caused by there being very little energy in the "ears" of a half sinewave.

For historical interest, I've included the old half wave "Thyratron" phase-control response in Fig. 2. Because of its limited range and its big no-no of drawing direct current out of the AC power line, that circuit became obsolete in the early sixties as full wave Triacs and other solutions became practical. In fact, as of July 1997, the circuit is illegal in Europe per the EN60555 standard. In the US, a similar IEEE 519 standard is pending.

Anyway, back to our discussion: A half-wave circuit can conduct only on the positive cycles, so it can deliver only one half of the available power. Note that half power is 0.707 voltage on a sinewave, so your maximum half-wave rms voltage on a 117-volt line is 83 volts or so. Also note how badly any average responding meter under-reports your system power, especially at low levels and late conduction angles.

For instance, we see that at an angle of 125 degrees, the true rms voltage is 32, while a typical average meter will report 12 volts—an error of 267%! Listing 1 and additional examples are available ready-to-use as my file FIND-RMS.PS, while your actual code used to generate Figs. 1 and 2 can be extracted from MUSE113.PSL.

Pager Vibrators

Here's one that sure hit me from way out in left field. There have been some recent Helpline requests for more information on pager vibrators, also called pager motors. Apparently there's a few new robotics or personal warning-device possibilities for these.

My personal fire pager is older and lacks one of these, so I did not have a clue where to begin. Some possibilities were *Mobile Radio Technology*, *Telecom* and *The Mart* magazines. A company called Endicott Coil used to make keyboard clickers, but I have not checked into them recently. To attack the robotics angle, there is Mondo-tronics for the parts and *Robotics Digest* magazine for ads and technical information.

Unfortunately, all of those seemed somewhat short of the mark. These days, to pick up instant answers, you always go to the Web. Start with the

```
% POSTSCRIPT RMS VALUE FINDER
% ================================================================
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% Thatcher AZ, 85552. (520) 428-4073 www.tinaja.com  don@tinaja.com
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% ================================================================

% Consulting services available on concepts shown.
% Two-way recordable comm is **REQUIRED** for these utilities.

% Routines excerpted from FINDRMS.PS on www.tinaja.com...

/scaleamp  117 2 sqrt mul def     % use a 117 volt ac cycle
/startang 0 def                   % set limits
/stopang 180 def                  %
/endang  180 def                  %
/res 0.1 def                      % step resolution in degrees

% Assume a ONE OHM load. Make a normalized array holding the desired
% waveform values. This routine optimizes for ac phase control.
% Any values array normalized to peak = 1 can be substituted...

/makewaveform {/waveform mark 0 res endang {/ang exch store ang
startang gt ang stopang lt and {ang sin} {0} ifelse} for] def } def

% do the rms and average calculations on the waveform array...

/findrms1 { 0 waveform {add } forall  waveform length div
/normaverage exch store 0 waveform {dup mul add} forall waveform
length div sqrt /normrms exch store normrms normaverage dup 0 eq {pop
0.000001} if div /normratio exch store} def

% report the results...

/crlf true def                    % IBM or sanity?
/return {(r) print crlf {(n) print} if} def

/reportrms {return return (The average normalized waveform value is )
print normaverage 20 string cvs print return return

(The rms normalized waveform value is ) print normrms 20 string cvs
print (.) print  return

(The ratio of rms to average is ) print normratio 20 string cvs print
(.) print  return return

(The average scaled waveform value is ) print normaverage scaleamp
mul 20 string cvs print (.) print return return

(The rms scaled waveform value is ) print normrms scaleamp mul 20
string cvs print (.) print return return return} def

/findrms {findrms1 reportrms} def % convenience linker

% ==========  demo - remove or alter before reuse.  ==========

%  (A) Plot the rms voltage versus phase angle for a triac that
%      conducts only a portion of each ac half cycle

/res 0.1 def                      % 0.1 degree accuracy
/startang 0 def                   % start at turnon angle
/stopang 180 def                  % go to the end of half cycle
/endang 180 def                   % stop at one half ac cycle
/scaleamp  117 2 sqrt mul def     % use a 117 volt ac cycle

0 10 180 { /startang exch store (The phase angle is ) print startang
20 string cvs print ( degrees.) print return makewaveform findrms}
for flush

% should return these edited results...

      %%  The phase angle is 0 degrees.
      %%  The rms voltage is 117.0.
      %%  The ratio of rms to average is 1.11072.

      %%  The phase angle is 10 degrees.
      %%  The rms voltage is 116.936.
      %%  The ratio of rms to average is 1.11852.

                << more stuff here >>

      %%  The phase angle is 170 degrees.
      %%  The rms voltage is 3.94639.
      %%  The ratio of rms to average is 4.88476.

      %%  The phase angle is 180 degrees.
      %%  The rms voltage is 0.0.
      %%  The ratio of rms to average is undefined.
```

LISTING 1—YOU CAN EASILY FIND THE rms and average voltages or currents for any waveform using this powerful PostScript-as-language routine.

PAGER VIBRATOR RESOURCES

Cellular Business
9800 Metcalf
Overland Park, KS 66212
(913) 341-1300

Endicott Coil
24 Charlotte Street
Binghamton, NY 13905
(607) 797-1263

The Mart
899 Presidential #110
Richardson, TX 75081
(800) 864-1155

Micro Mo Electronics
14881 Evergreen Avenue
Clearwater, FL 34622
(813) 572-0131

Mobile Radio Technology
9800 Metcalf
Overland Park, KS 66212
(913) 341-1300

Mondo-tronics
524 San Anselmo Ave #107
San Anselmo, CA 94960
(800) 374-5764

Motorola Communications Prods
1301 E Algonquin Road
Schaumburg, IL 60196
(800) 668-6752

Namiki
201 W Passaic Street
Rochelle Park, NJ 07662
(201) 368-0123

Pageco
2400 E Comm Blvd #630
Ft Lauderdale, FL 33308
(954) 776-0031

Robotics Digest
966 Elm Street
Rocky Ford, CO 81067
(719) 254-4558

Surplus Traders
PO Box 276
Alburg, VT 05440
(514) 739-9328

Telecom
1020 Church St
Evanston, IL 60201
(847) 475-1900

"search all sites" top button on my Web-Related Utility Links page. Punch on down into Alta Vista, and then enter "pager vibrator" or "pager motor". Presto, instant results!

We found that Namiki is the leading manufacturer. A typical model is their 6CV-1501WL-00. This gem is six millimeters in diameter and only fifteen millimeters long. The 1.3 volt motor runs at 7000 rpm. Which translates to 116 "whumps" per second. A companion tungsten counterweight is included.

Motorola apparently uses Namiki pagers internally as their part number 5950-46803. A second pager-vibrator supplier is Micro-Mo.

The Net also tells us that these are a tad pricey, being something like $17 in singles. One smaller quantity reseller is PageCo. Also, Surplus Traders has these in huge quantities, but only on a when-and as-available basis.

A few of these useful pager motor contacts are shown in this month's resource sidebar. Be sure to tell me about any new uses you can come up with for these, or if you find a super cheap source for them.

NAMES AND NUMBERS

Adobe Acrobat
1585 Charleston Rd
Mountain View, CA 94039
(800) 833-6687

Alps Electric
3553 North First Street
San Jose, CA 95134
(408) 432-6000

Antique Power
Box 838
Yellow Springs, OH 45387
(937) 767-1433

Cryptosystems Journal
485 Middle Holland Rd
Holland, PA 18966
(215) 579-9888

Damark
Box 29900
Minneapolis, MN 55429
(800) 729-9000

Machinery Dealers National Association
1110 Spring Street
Silver Spring, MD 20910
(301) 585-9494

Magnetic Research
122 Bellevue Ave
Butler, NJ 07405
(201) 838-6348

Maxim
120 San Gabriel Dr
Sunnyvale, CA 94086
(800) 998-8800

Metal Buyers Mart
N15 W22218 Watertown Rd #3
Waukesha, WI 53186
(800) 657-0721

Ragtime
4218 Jessup #AB
Ceres, CA 95307
(209) 668-0366

Recharger
4218 W Charleston Blvd
Las Vegas, NV 89102
(702) 438-5557

Synergetics
Box 809
Thatcher, AZ 85552
(520) 428-4073

TelCom Semiconductor
1300 Terra Bella Avenue
Mountain View, CA 94043
(415) 968-9241

TriTech Micro
1440 McCandless Drive
Milpitas, CA 95035
(800) 253-8900

Videogame Advisor
64 Danbury Road, Ste 500
Wilton, CT 06897
(203) 761-6150

Vision Systems Design
10 Tara Blvd, 5th Floor
Nashua, NH 03062
(603) 891-0123

Names & Numbers

First this month, from Maxim, there's a new Product Data Sheets CD. TriTech Microelectronics has data sheets on several intriguing new chips, such as a TR88801CS pen input conditioner, a 89101 Caller ID interface, and their TR83100CF voice-storage processor.

From TelCom Semiconductor comes a Thermal Management Guide on all of their electronic thermostats and temperature sensors. Wireless remote game controllers are being distressed out by Damark at $50 each. Those would appear to offer all sorts of unusual short range data-communications possibilities.

How about player pianos that are now fully MIDI compatible? For full details, you can contact the folks at Ragtime.

The great *Magnetic Measurements Handbook* has been newly revised by Jack Janicke of Magnetic Research. You'll find plenty of fluxgate information

there. Tony Patti has released the fourth volume of his ongoing self-published *CryptoSystems Journal.*

From MDNA comes the *Used Machinery Buyers Guide*. For largish pieces of metal in smaller quantities, check out *Metal Buyers Mart.*

New trade journals for this month include *Vision Systems Design* and *Videogame Advisor.* If you are really into hardware, look into *Antique Power* magazine; it's mostly on restoring steam tractors. There's also a sister publication with the subtle name of *Old Truck.* There's some amazing stuff in both.

For the insider secrets of starting up your own technical venture, check my *Incredible Secret Money Machine II* as per my nearby Synergetics ad. Also visit my Guru's Lair Web site at www.tinaja.com I have just added a mass teleportation update there as file RESBN63.PDF, plus font conversion tools PFA2PFB.PS and PFB2PFA.PS. Most items mentioned appear in the Names & Numbers or the Pager-Vibrator Resources sidebars. Be sure to check there first before calling our no-charge US technical helpline. Let's hear from you! EN

WHAT'S NEWS

continued from page 6

More information about Wescon/IC Expo is available by calling 1-800-877-2668, or online at http://www.wescon.com.

Electronics Reliability Testing

Many existing and emerging technologies, including industrial robots and medical electronic implants, face a critical need for low-cost, rapidly achievable, electronics-reliability testing. Sandia National Laboratories' Electronics Quality/Reliability Center (EQRC) provides industry with easy access to Sandia's electronics reliability expertise, garnered in part from its role of ensuring the ultra-reliability of nuclear weapons electronics.

Sandia conducts one of the world's largest electronics reliability/failure-analysis programs. The EQRC, which concentrates on working with small businesses, has a technical staff of 30 "real-world" experts, and includes more than 40 major pieces of equipment valued at $10 million.

EQRC users can measure stresses on semiconductor devices using x-ray diffraction, test large numbers of devices to generate statistically significant results, or measure both the currents and voltages on ICs. A manufacturer can discover reliability problems before incurring the high costs of "dicing up" and packaging ICs by performing wafer-level reliability tests on up to 8-inch wafers. The Sandia-developed Charge Induced Voltage Alteration (CIVA) techniques locate open circuits in complex ICs in as little as 15 minutes to an hour, compared with traditional failure-analysis techniques that take weeks or even months. EN

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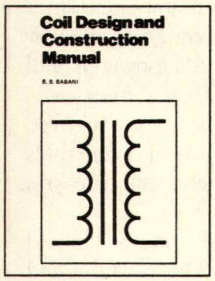

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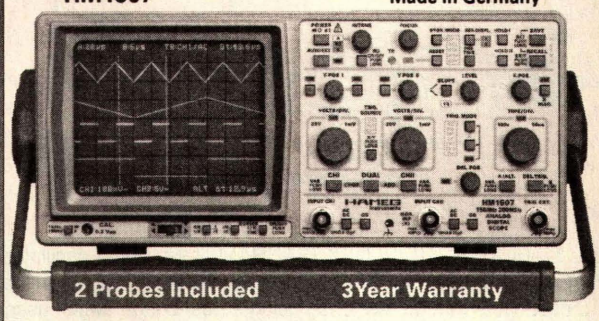

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BY FRANKLIN J. MILLER

Build Your Own Audio Oscillator

ONE OF THE MOST IMPORTANT PIECES OF AUDIO TEST EQUIPMENT THAT YOU WILL EVER OWN IS AN AUDIO OSCILLATOR. IN THIS COLUMN I WILL SHOW YOU THE BASICS OF BUILDING ONE FOR YOURSELF. IT IS THE FIRST OF A SERIES OF AUDIO test instruments that will be discussed in the coming months.

For those that are regular builders, you know that making your own test instruments, having them work well, and having them look impressive to others can be extremely satisfying. It can also save you a lot of dollars. For those that rarely, if ever, build, why not give this a try; along the way, I will do my best to help you overcome some of the typical frustrations that newcomers face.

Part of my job as the author is to work all the kinks and bugs out of the design and make the instrument easy to duplicate. To make that happen, I have used standard, easily available parts wherever possible. Occasionally some specialized part is needed to make the project work properly. Whenever that happens, the part is fully identified. In addition, I will make sure that the part is available, at a reasonable cost. I will also make available a complete kit of all parts for those readers who prefer that approach.

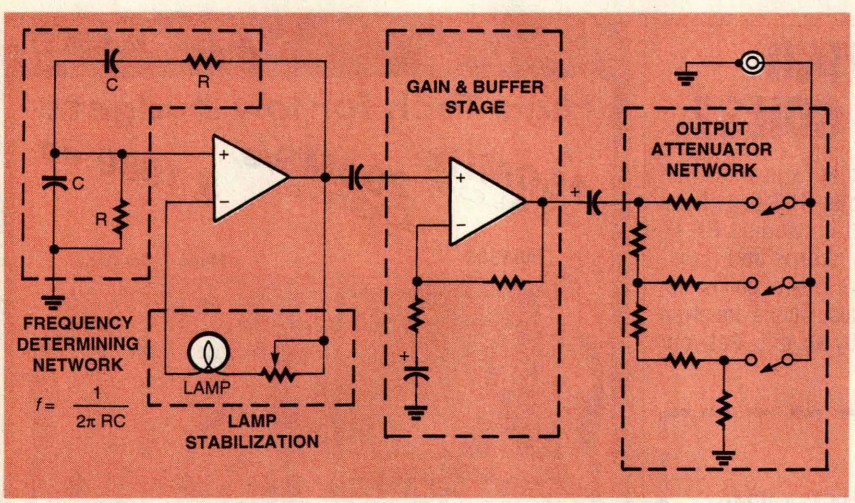


FIG. 1—HERE'S THE BLOCK DIAGRAM of our audio oscillator. The parts designated R and C in the frequency-determining network actually represent banks of precision resistors and capacitors that are switched using a pushbutton switch assembly.

The simple audio oscillator we are about to describe is needed to test all kinds of audio devices. While researching the different types of oscillators that might lend themselves to this task, I discovered that a Wien type was the best choice. One of its advantages is that by changing the values of two precision resistors or capacitors, the output frequency can be easily varied.

The Simple Audio Oscillator

My Wien-type circuit generates four basic frequencies and uses them to cover the entire audio band, and somewhat beyond. Although once we get outside of the fundamental 20—20,000 Hz range, output-signal amplitude is no longer constant. The unit is controlled using three banks of switches—one to set the frequency, one to set the multiplier, and one to select the output level. The output itself is an unbalanced low-impedance type that will drive loads of 600 ohms or greater. The unit is AC powered and physically small (2½-inches high, 4½-inches deep, and 8-inches wide). It is also inexpensive to build. Ordinary hand tools and soldering equipment will help you complete the job.

As I stated, the oscillator is a standard Wien bridge circuit. The resistors and capacitors used in the frequency-determining part of the circuit (the bridge itself) should be high-tolerance parts. I used 1% resistors and 5% capacitors in the design. Also, the more closely you match the resistors and capacitors, the lower the distortion the circuit produces. The oscillator frequency is set using the formula:

$$f = 2\pi RC$$

If we choose the capacitance carefully, a range of 1000:1 becomes practical. However, I chose to switch capacitors in BCD (Binary-Coded Decimal) format to produce whole-number frequencies (more on the switching scheme in a moment). That produces a very large range of possible frequencies from an

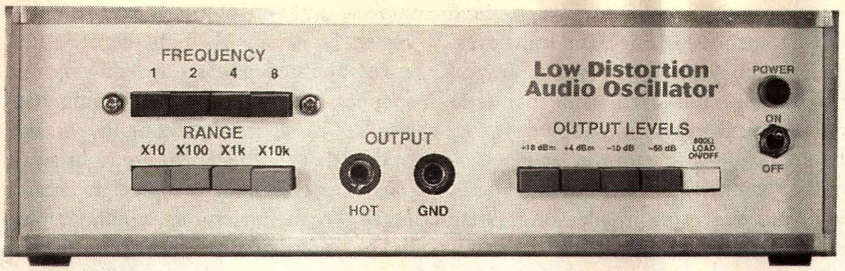


FIG. 2—HERE'S THE FRONT-PANEL layout for the instrument. The frequency and range selector switches discussed are on the left-hand side.

instrument that is small and inexpensive.

The exact frequency is determined by the tolerance of the components. For example, if we set a test frequency of 1 kHz and the true exact frequency is 1057 Hz, will it affect the readings? The answer is probably not. Of course that might not be true if we were trying to set up a crossover or some filter circuit where a more precise standard is needed.

ORDERING INFORMATION

The following items are available from Franklin J. Miller, 2100 Ward Dr., Henderson, NV 89015: A complete kit of all parts, including case, circuit boards, front panel label, $110.00; a partial kit of essential parts (pre-punched case, two circuit boards, three pushbutton-switch assemblies, and front-panel label), $45.00. Shipping in US included.

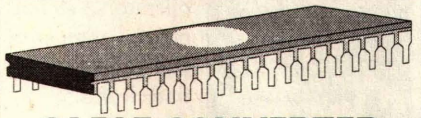
Frequency-Selector Switches

Two switch banks are used to select the generator's output frequency. The top bank (see Fig. 2), marked FREQUENCY, changes the resistor values in the Wien Bridge. Note that the switches are labeled 2, 4, 8, and 16. They are additive. So if you push 2 and 4 you get 6. If you push 2, 4, and 16, you get 22. The lower bank of switches, labeled RANGE is the range selector. Those switches are marked X1, X10, X1K, and X10K. Only one switch can be depressed at a time in this bank. So to select a 10,000-Hz output, we would depress 2, and 8 (= 10) in the top bank, and X1K in the bottom bank. No, you cannot select every specific frequency—for example, 33 Hz and 77 Hz are not available. But more than enough frequencies are available, and I felt the trade-off was worthwhile to keep the cost down

The switching arrangement is really handy if you want to look at amplifier performance at two different frequencies. Just set up the first and look at the output from the amplifier. Then switch frequencies and see what happens to the output.

Getting Started

You have a variety of choices in building your oscillator. You can order a complete kit of all parts; a partial kit consisting of the unit's two PC boards, three pushbutton switch assemblies, pre-punched cabinet, and preprinted front-panel label; or you can build your own from scratch. For those interested in the complete or partial kits, details are in the Ordering Information box. If you want to build your own from scratch, the next column will present the foil patterns, full schematic, and a detailed parts list. See you then. EN



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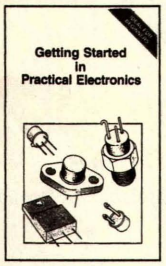

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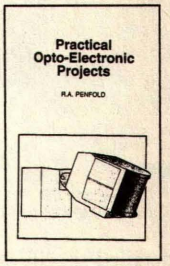

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NEW LITERATURE

continued from page 19

RF & Microwave Test Accessories Catalog

Hewlett-Packard Company
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Palo Alto, CA 94304
Tel: 1-800-452-4844, ext. 5085
Web: http://www.tmo.hp.com/tmo/catalogs
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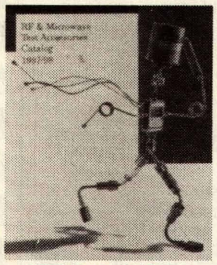
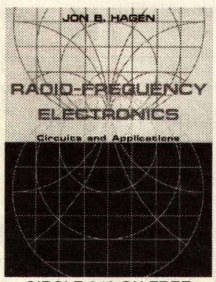


CIRCLE 341 ON FREE INFORMATION CARD

The products featured in this catalog include step and fixed attenuators, amplifiers, detectors, couplers, switches, and switch drivers. The catalog also provides application discussions, detailed specifications, dimensions, photographs, and product-family overviews. Alphabetical and product-number indexes are included.

Radio Frequency Electronics: Circuits and Applications

by John B. Hagen
Cambridge University Press
40 West 20th Street
New York, NY 10011-4211
$49.95



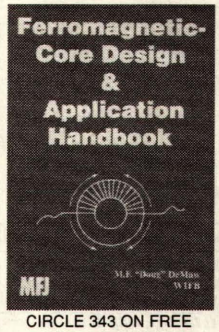
CIRCLE 342 ON FREE INFORMATION CARD

This comprehensive book provides an introduction to the basic concepts and key circuits of radio-frequency systems. It covers the fundamental principles that apply to all radio devices, from wireless data transceivers on semiconductor chips to high-power broadcast transmitters. Intended primarily as a textbook for junior and senior courses in electrical engineering, the book also serves as a valuable reference tool for researchers and professional engineers, or for those moving into the field of wireless communications.

Topics include filters, amplifiers, oscillators, matching networks, modulators, low-noise amplifiers, phase-locked loops, transmission lines, and transformers. In each subject, important physical insights are emphasized, while maintaining analytical rigor. The book describes the applications of radio-frequency systems in such areas as communications, radio and television broadcasting, radar, and radio astronomy. It also contains many exercises designed to help readers reach a clear understanding of the material presented.

Ferromagnetic-Core Design & Application Handbook (MFJ-3506)

by M.F. "Doug" DeMaw, W1FB
MFJ Enterprises, Inc.
300 Industrial Park Road
Mississippi State, MS 39762
Tel: 601-323-5869 or 1-800-647-1800
Fax: 601-323-6551
Web: http://mfjenterprises.com
$19.95



CIRCLE 343 ON FREE INFORMATION CARD

Amateur-radio operators, technicians, engineers, and students will find clear information on the practical aspect of magnetic-core materials from low frequency to UHF in this book. It provides an in-depth understanding of basic theory, along with many practical circuit examples that use toroids, rods, and pot cores made of ferrite and powdered iron. All circuits were proven in the lab by the author.

The book teaches readers about proper core selection versus operating frequency, circuit Q, power-handling capability, and physical mass. It shows how to avoid using the wrong core material or misapplying the right core material, which can ruin a perfectly good circuit.

Tedious mathematics have been omitted. To make the material easier to understand, equations are used only when needed to illustrate a concept or design example. The book contains many examples of narrow-band and broadband transformers and inductors. Ferrite loop antennas, slug-tuned inductors, RF chokes, and ferrite beads are also discussed in detail. Magnetic-core devices are highlighted in filters, switching power supplies, and impedance-matching networks. Five appendices contain a wealth of data that can be put to use right away, including comprehensive design data, a list of core manufacturers, a bibliography, design, nomographs, conversion tables, and component numbers and characteristics from a number of manufacturers.

1997 Test and Measurement Product Guide

Tucker Electronics
P. O. Box 551419
Dallas, TX 75355-1419
Tel: 1-800-527-4642
Web: http://www.tucker.com
Free

CIRCLE 344 ON FREE INFORMATION CARD

This catalog features nearly 200 pages of new and reconditioned test and measurement products. Highlighted in the 1997 30th Anniversary Edition are an expanded new product line that includes Tektronix benchtop and handheld tools, and an upgraded reconditioned product line with later or "newer model" instruments. Product categories include meters, oscilloscopes and accessories, power supplies, television and video equipment, tools and toolkits, lightwave instruments, counters and frequency standards, analyzers, avionics testers, component testers, and RFI/EMI equipment.

Java Database Programming

by Brian Jepson
John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10158-0012
Tel: 1-800-225-5945
Web: http://www.wiley.com
$29.95

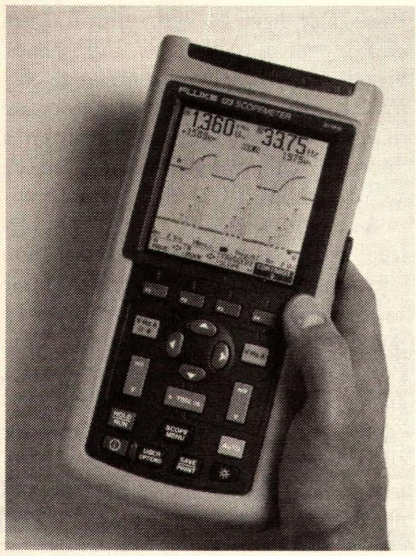
This complete guide to mastering the next generation of database-programming technologies teaches readers the

continued on page 60

NEW PRODUCTS

continued from page 20

checks, but also shields the incoming signal from noise pickup. The same test lead functions as an oscilloscope probe for wide bandwidth displays. That feature speeds up the troubleshooting process, as the user no longer has to swap leads to make different measurements.



CIRCLE 21 ON FREE INFORMATION CARD

Fully integrating the capabilities of a DMM and an oscilloscope means that oscilloscope waveforms and DMM readouts are displayed simultaneously, on both channels. The user can access 26 common scope and meter measurements from a simple menu list. The oscilloscope has a 20-MHz bandwidth, and the multimeter is a true-rms, dual-channel, 5000-count DMM with 0.5% accuracy.

The dual-channel TrendPlot recording function makes it easier for technicians to see trends and isolate intermittent patterns or those that occur during "off" hours. It works like a chart recorder to help identify those faults by recording readings—such as volts, amps, temperature, frequency, phase, and even resistance or capacitance—over time.

The ScopeMeter 123 can store two screen images and up to ten user setups in non-volatile memory, and includes an RS-232 interface for printing or downloading measurements to a PC for further analysis. Full compatibility with FlukeView for Windows software makes it easy to document, analyze, and archive measurements.

The ScopeMeter 123, complete with a line adapter/charger, shielded test leads, alligator clips, hook clips, rechargeable battery pack, and user's manual, has a list price of $995.

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E-mail: fluke-info@tc.fluke.com
Web: http://www.fluke.com

Tape-Deck Cleaner/Demagnetizer

According to Trackmate, its Audio HyperBRUSH Pro tape-deck cleaner and demagnetizer can reduce the fuzzy, hissing sounds associated with audio cassette decks. It uses a patented five-brush process to clean the key areas that other products cannot reach.

Dirt, dust, and oxides that collect in the mechanism of a tape deck can cause the music to sound fuzzy and irregular. Traditional cleaning tapes only touch the crown of the audio head—which is already "buffed clean" each time a standard tape runs through the machine. The flexible HyperBRUSH system uses woven fiber brushes, housed in cassette shells, to automatically and safely clean and maintain the critical inner components of the tape deck. The system form-fits the components in order to remove dirt from the area touched by the audio tape and beyond, where harmful deposits collect. It also removes magnetic fields that build up on the tone head, which, if not cared for, can add to the hissing sounds.

CIRCLE 22 ON FREE INFORMATION CARD

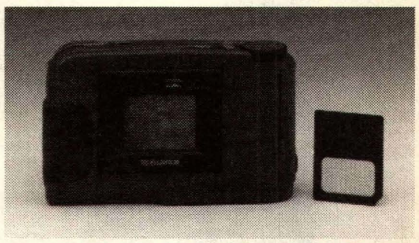
The HyperBRUSH system uses five mechanically driven brushes that seek and remove dirt from the component surfaces, grooves, and gaps. The user simply applies isopropyl alcohol from the included applicator pen on to the brushes, places the cassette into the machine, and presses "play." Within 10 to 15 seconds, the system gently removes accumulated dirt using a patented "soak-scrub-soak" cleaning action. Soiled brushes can be removed, washed, and reused.

The Audio HyperBRUSH Pro has a suggested retail price of $14.95.

TRACKMATE
5209-B Davis Blvd.
North Richland Hills, TX 76180
Tel: 817-281-1694 or 1-800-486-5707
Fax: 817-428-0567

LCD Digital Camera

The Fujifilm DS-7 digital camera features a 1.8-inch active matrix color LCD that makes composing photographs fast and easy—and lets you see the results immediately. You can capture an image, view it on the LCD monitor, and delete it on the spot or save it to a 2MB solid-state floppy-disk card (SSFDC) called "SmartMedia." Each card stores up to 30 images in standard mode and up to 60 in the economy mode. The DS-7 never runs out of memory—just slip in another SmartMedia card.



CIRCLE 23 ON FREE INFORMATION CARD

Stored images can be played back on the camera's LCD or on a TV, downloaded to a PC or Macintosh via cable, or accessed instantly at hard-disk speed on a laptop using the SmartMedia card and an optional PC-card adapter, which fits into any PCMCIA type II slot. Once the images are downloaded (in JPEG format), they can be edited using the included Adobe PhotoDeluxe image-editing software, inserted into other applications, and posted on the Internet.

The DS-7's color charge-couple

device (CCD) has 350,000 square pixels. With its support for the square 1:1 pixel VGA standard used in PCs, the CCD eliminates the need for post-processing in the camera. A unique RGB color filtration method allows for accurate color reproduction.

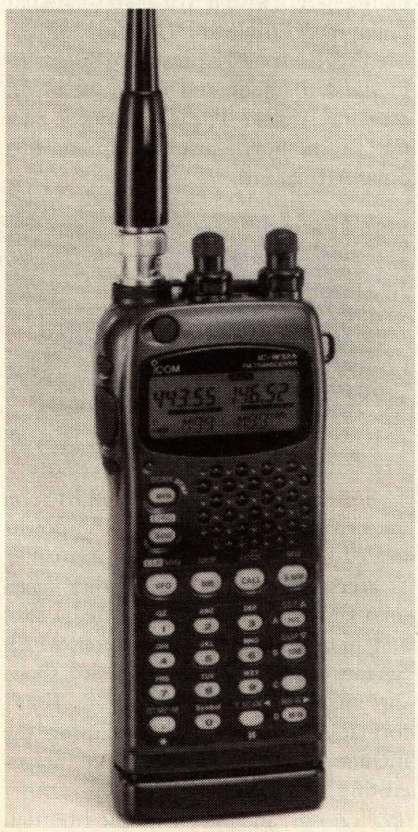
The digital camera delivers full-frame, color images with 640 by 480 resolution. The DS-7 features a Fujinon lens and offers automatic exposure. Other features include portrait, landscape, macro, and low-light settings.

The DS-7 digital camera with LCD monitor has a suggested retail price of $699.

FUJI PHOTO FILM U.S.A., INC.
555 Taxter Road
Elmsford, NY 10523
Tel: 1-800-378-3854
Compuserve: Go Fuji

Dual-Band Handheld Transceiver

Icom's ultra-slim IC-W32A dual-band transceiver fits comfortably in the hand and meets the needs of both experienced and novice operators. A total of 200 memories can be displayed by either frequency or name. Up to eight alphanumeric characters can be programmed for quick and easy identification on the LCD. Each band has 100 memory channels, and four DTMF memories have up to 16-digit capability.



CIRCLE 24 ON FREE INFORMATION CARD

You can receive both VHF and UHF bands simultaneously—and both frequencies can be viewed on the display—or use the V/V and U/U functions to receive two frequencies on the same band. You can transmit on either operating band. The IC-W32A has separate tuning and volume controls on the top panel to allow independent adjustment of each band. Icom's versatile VHF/UHF exchange function allows you to assign VHF/UHF tuning and volume to either knob. Frequency coverage is 144- to 148-MHz and 440- to 450-MHz transmit, and 118- to 174-MHz and 400- to 470-MHz receive.

The easy-to-use IC-W32A features a new guide function that allows quick description of the key function without searching a menu list. No function button means simple programming. Additional features include three levels of power output, multiple power-saver functions, large backlit keys, and full crossband and duplex operation. Scanning functions include programmed, full, and memory skip scan. The IC-W32A also has ten U.S. weather channels and built-in tone squelch.

The IC-W32A has a suggested retail price of $479.

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COMPUTER CONNECTIONS

continued from page 22

capacitors. To add a shape to a drawing, you drag it from the stencil, and drop it in the work area. Intelligent connectors allow you to move shapes around and retain the lines connecting them. You can have multiple stencils and multiple drawing files open simultaneously. Each drawing file may have multiple pages. Pages may have backgrounds. You can create your own stencils and shapes. Shapes can have intelligence and customized data fields, so it's easy to create things like a bill of materials from a drawing. The overall package can be automated through OLE Automation.

Visio has diverged into two nonoverlapping subproducts, Visio Pro and Visio Technical. Both versions follow the same basic interface; they are distinguished by the stencils and wizards included. Visio Pro is for business analysts, software engineers, Web site developers, and database designers. Visio Technical is for everyone else; it is for diagramming electronic schematics and electrical and mechanical layouts. EN

NEW LITERATURE

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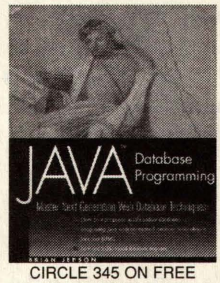

CIRCLE 345 ON FREE INFORMATION CARD

critical new Java database technologies and tools, including Sun Microsystems' Java Database Connectivity (JDBC) standard. It presents practical, step-by-step techniques with which you can harness the Java programming language. The book also explains how to create dynamic database applications and applets.

The book examines how Java programs access online databases. It shows how to integrate Java with networked database technologies. It teaches readers how to program with JDBC and how to develop JDBC drivers. The book also presents Java database tools and code libraries. The supporting Java Database Programming Web site offers tinySQL, a generic and extendible SQL engine written in Java; the tinySQL JDBC driver; and customizable Java database code. EN

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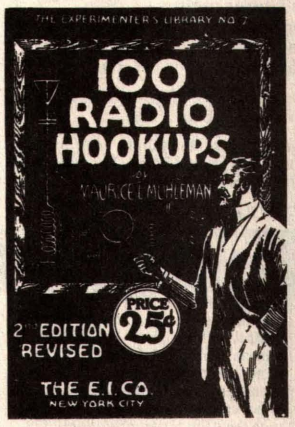
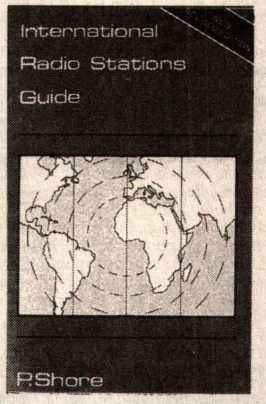
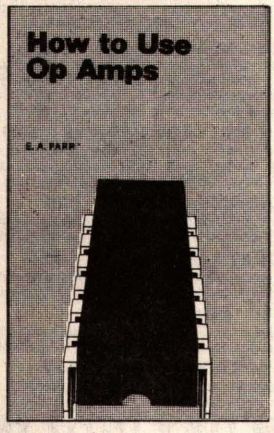
First published in May, 1923 this popular booklet went into reprint editions nine times. It is packed with circuits, theory, antenna installation and tips on consumer radio receivers that were popular in the early 1920's. Antique radio buffs and those inquisitive about the early days of radio will find this booklet an exciting, invaluable and excellent reference into the minds of early-day radio listeners. Sorry, we cannot honor the original 25-cent cover price.



☐ INTERNATIONAL RADIO STATIONS GUIDE—BP255 —$9.95

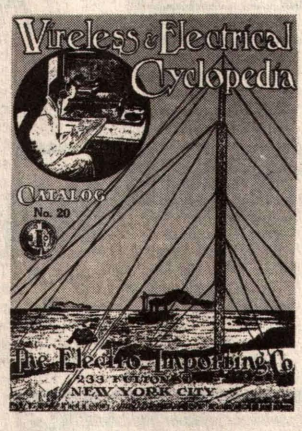
Provides the casual listener, amateur radio DXer and the professional radio monitor with an essential reference work designed as a guide for listening tothe complex radio bands. Includes coverage on Listening to Shortwave Radio, ITU Country Codes, Worldwide Radio Stations, European Long Wave and Medium Wave Stations, Broadcasts in English and more.





☐ HOW TO USE OP AMPS —BP88—$5.95

The engineer's best friend is the op amp. This basic building block is found in many circuits, analog and digital alike. The op amp finds many useful purposes such as: oscillators, inverters, isolators, high- and low-filters, notch and band-pass filters, noise generator, power supplies, audio, MIDI, and much more. Prepared as a designer's guide, some limited math is used, however engineers and hobbyists alike find it a useful text for their design needs.



☐ WIRELESS & ELECTRICAL CYCLOPEDIA —ETT1—$5.75

A slice of history. This early electronics catalog was issued in 1918. It consists of 176 pages that document the early history of electricity, radio and electronics. It was the "bible" of the electrical experimenter of the period. Take a look at history and see how far we have come. And by the way, don't try to order any of the radio parts and receivers shown, it's very unlikely that it will be available.

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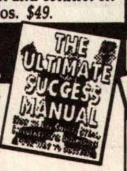

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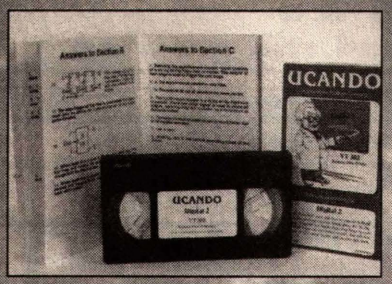

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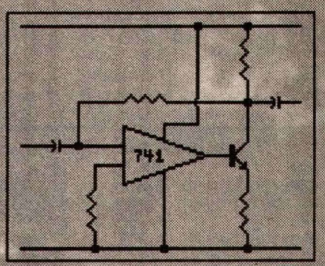
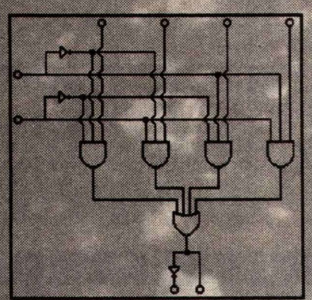
MODEL	DESCRIPTION	REGULAR	SALE
VT201	Direct Current: Series circuits, Parallel Circuits, Ohm's law, how to use the DMM. 55 Minutes	44.95	39.95
VT202	Alternating Current: The sine wave, coils, capacitors, transformers. 62 minutes	44.95	39.95
VT203	Semiconductors: Semiconductor theory, common diodes, transistors, switching devices. 57 Minutes	44.95	39.95
VT204	Power Supplies: Rectifier circuits, filter circuits, regular circuits, troubleshooting. 56 Minutes.	44.95	39.95
VT205	Amplifier: Amplifier basics, class A, class B, class C, operational amplifiers. 57 Minutes	44.95	39.95
VT206	Oscillators: LC and RC oscillators, crystal oscillators, crystal ovens. 56 Minutes	44.95	39.95



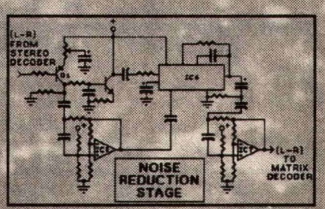


Digital Series

MODEL	DESCRIPTION	REGULAR	SALE
VT301	Digital 1: Digital basics, basic gates, binary notation, binary math, decimal notation. 54 Minutes	44.95	39.95
VT302	Digital 2: Octal notation, hexadecimal notation, flip-flops, counter circuits. 55 Minutes	44.95	39.95
VT303	Digital 3: Complement numbers, multiplexers, registers, decoder drivers, displays. 56 Minutes	44.95	39.95
VT304	Digital 4: R-2R DAC circuits, binary weighted no.s, slope circuits, S/A & flash circuits. 57 Minutes.	44.95	39.95
VT305	Digital 5: Memory devices, ROM, PROM, EPROM, EEPROM, SRAM, DRAM, MBM. 56 Minutes	44.95	39.95
VT306	Digital 6: The central processing unit, input devices, output devices. 56 Minutes	44.95	39.95

Other Popular Videos

MODEL	DESCRIPTION	REGULAR	SALE
VT401	AM Radio: Major stages of AM, signal conversion, signal detection, audio reproduction, AM stereo. 61 Minutes	44.95	39.95
VT402	FM Radio Part 1: Bandwidths, RF amplifier, mixer-oscillator, IF amplifier, limiter FM detector. 58 Minutes	44.95	39.95
VT403	FM Radio Part 2: Frequency doubler, stereo demultiplexer, audio amp stages, digital data encoding/decoding. 58 Minutes	44.95	39.95
VT404	TV Part 1, Intro to TV: Gain an overview of the television system and how the stages work together. 56 Minutes	44.95	39.95
VT405	TV Part 2, The Front End: UHF-VHF tuning stages, automatic fine tuning, remote control. 58 Minutes	44.95	39.95
VT406	TV Part 3, Audio: The sound strip, stereo TV, secondary audio programming, professional channels. 57 Minutes	44.95	39.95
VT501	Understanding Fiber Optics: Basic fundamentals, cable design, connectors, couplers, splicing. 58 Minutes	44.95	39.95
VT502	Laser Technology: Laser theory, types of lasers, applications, safety precautions. 57 Minutes	44.95	39.95
VT102	Intro to VCR Repair: This video is designed for the serious technician. (workbook not available). 84 Minutes	44.95	39.95
VT103	Learn How To Clean Your Own VCR: This video is not technical, but will save you money. (workbook not available). 32 Minutes	29.95	25.95



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POLYGON MOTOR UNIT & DRIVER $79.00
Ten-sided first surface mirror mounted on an armature that spins at 125 revolutions per second yielding a beam sweep rate of 1250 sweeps per second. The driver for the polygon unit requires 24 volts and plus and minus 12 volts to operate. There is also an f-theta lens in front of the polygon scanning mechanism with a three inch diameter. Great for optical experiments, etc. Very high quality units. **(MFR: JAPAN ELECTRONICS)**

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16 bit • 4 Mbps • IEEE 802.2 and 802.5 compatible • twisted pair • interoperable with IBM Token Ring network

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These transceivers were designed for operation in an AMPS (Advanced Mobile Phone Service) cell site. The 20 MHz bandwidth of the transceiver allows it to operate on all 666 channels allocated. The transmit channels are 870.030-889.980 MHz with the receive channels 45 HMz below those frequencies. A digital synthesizer is utilized to generate the selected frequency. Each unit contains two independent receivers to demodulate voice and data with a Receive Signal Strength Indicator (RSSI) circuit to select the one with the best signal strength. The transmitter provides a 1.5 watt modulated signal to drive an external power amplifier. channel selection is accomplished with a 10 bit binary input via a connector on the back panel. Other interface requirements for operation are 26 VDC (unregulated) and an 18.990 MHz reference frequency for the digital synthesizer. The units contain independent boards for receivers, exciter, synthesizer, tunable front end, and interface assembly (which includes power supplies and voltage-controlled oscillator). Service manual, schematics and circuit descriptions included.

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Note: We have not been able to bypass an access code in the software. Thus, while time of day and other introductory things are displayed on LCD, the full original capabilities of this unit cannot be guaranteed. Also, we do not have a source for the smart cards that were to go in the PCM CIA sockets. Requires 12 volt adapter for power. (Not included) Dimensions: 9-1/2L x 6-1/4W x 2-1/2 D • Original cost over $450.00

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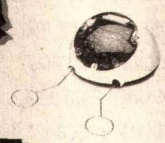

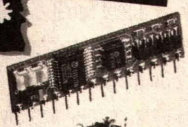

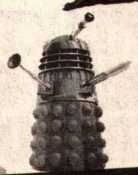

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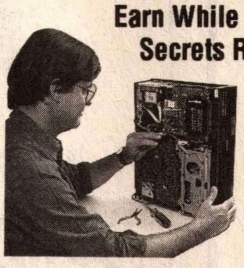

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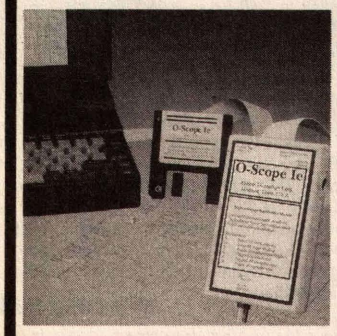

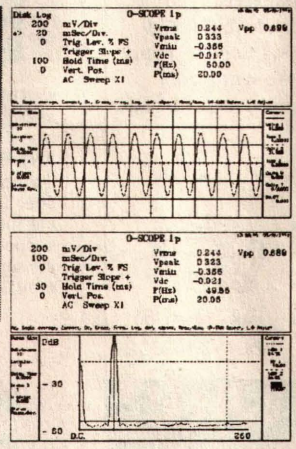

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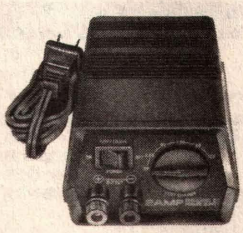
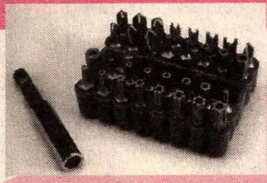


2A Selectable Voltage Power Supply
Ideal for powering projects, or for use as a battery eliminator. Regulated output is switchable to 3, 4½, 6, 7½, 9 or 12 volt.
#28-2200
Reg. $20.50 .....Only $14.95

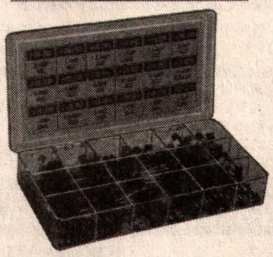
TENMA®
DMM With Temperature Function
Full function DMM measures AC/DC volts and current, resistance, capacitance and frequency. Also measures temperature from -4~752° F making it ideal for appliance repair.
#72-4030
Reg. $79.95 .....Only $44.00



32 Piece Security Bit Set NEW
Complete pocket sized set is compatible with most tamper proof fittings including security hex, torx, spanner and tri-wings. Ideal for servicing cable boxes, IBM PS/2 monitors, phone equipment and more.
#22-1875.....Only $14.95

Lead Wire Fuse NEW
Finally there is a fast, easy, low cost way to tap an automotive fuse box. The lead wire fuse greatly eases installation and virtually eliminates potential damage some fuse taps cause to fuse boxes.
Only $2.25

Order #	Amperage
60-3855	5
60-3860	7.5
60-3865	10
60-3870	15
60-3875	20
60-3880	25
60-3885	30



180 Piece ACG/GMA Fuse Assortment
Contains many fuses used when servicing electronic equipment. Contains 10 each of the most popular glass and ceramic fuses.
#102-005
Reg. $20.95 .....Only $14.95

VCR Model SuperCross™
Great for repair parts sourcing. Simply enter a VCR make and model to research and all makes that are mechanically the same are displayed.
#81-2055
Reg. $29.95 .....Only $24.95

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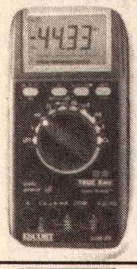


DMM

DMM-10 ($19.95): 3½ digit, DC/AC V, Ω, hFE, diode, signal output(+3V,-0.5Vsq.,50%duty)

DMM-17B ($39.95): 3½ digit,DC/ACV, contin., DC/ACA, Ω, Capacitance,hFE, diode, Freq

DMM-20 ($74.95): AC/DC (V, A), Freq, cont., Capac, Induct., Ω, hFE, diode, duty cycle

DMM-22 ($89.95): 4000counts, bar graph, Freq, AC/DC(V,A), Ω, Capacitance, diode, contin.

DMM-23T ($99.95): 4½ digit, high resol. (10uV, 10nA, 10mΩ), hFE, diode, contin., true rms

DMM-89S ($179.00): true rms, AC/DC (V,A), Ω, bar graph, freq, capac., dBm, logic, diode

DMM-113 ($24.95): Pocket Size, DC/ACV, Ω, diode, Continuity beeper

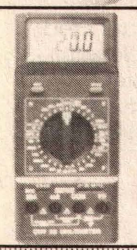
DMM-120 ($24.95): economy type, DCV,ACV, DCA, Ω,hFE, diode

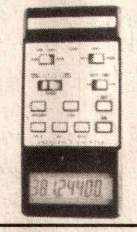
DMM-122 ($59.95): DC/AC(V,A), Ω, hFE, diode, capacitance, freq, logic, continuity

DMM-123 ($44.95): DMM + capacitance, DC/AC(V,A), Ω, hFE, diode, continuity

DMM-124 ($69.95): Electrical+Temp,DC/ACV, , capacitance, freq, 3 phase, diode, contin.

DMM-125 ($54.95): Autorange + bar graph, DC/AC(V,A), Ω, diode, continuity beeper





LCR METER

CAP-15 *($49.95)*: 3½ digit, 0.1pF-20mF, 9 Ranges, 0.1pF resolution zero adjustment.

LCR-195 *($89.95)*: 1uH-200H (induct.), 0.1pF-200uF(Capac.), 0.01Ω-20M Ω(resistance)

LCR-814 *($189.95)*: 0.1uH-200H, 0.1pF-20mF, 0.1Ω-20MΩ, Q Factor, dissipation, zero adjust

LCR-131D *($229.95)*: autorange, 0.1uH-10kH, 0.1pF-10mF, 1mΩ-10MΩ, Q Factor, serial/parallel, 120Hz/1kHz testing mode

FREQ. COUNTER

FC-1200 *($129.95)*: 1.25GHz Handheld, 8 digits display, 10ppm accurary, sensitivity 5mV (130-350MHz), 30mV (440MHz), 22m (800mhz), batteries or 9V adapter.

FC-5250C *($119.95)* 220MHz benchtop, 7 digit, 10ppm accuracy, 35mV sensitivity, 10Vp-p max input, power by 9V adapter

FC-5270A *($149.95)* 1.2 Ghz bench type, 8 digit, 10 ppm, 35mV sensitivity, 10Vp-p max. input, power by 9V adapter.

FC-5700 *($329.95)* 1.3GHz bench type, 8 digit, 1 ppm accuracy, 20mV sensitivity, period 0.1us to 100ms. Ideal for test & repair of audio instrument.

FLUKE DMM

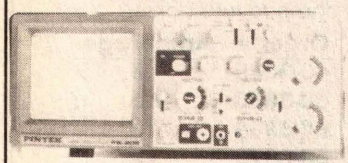
HandHeld		*Scope Meter*	
12	$ 84.95	**92B**	$1,399
70-II	$ 75.95	**96B**	$1,699
73-II	$ 97.95	**99B**	$1,999
75-II	$129.00	**105B**	$2,499
76-II	$175.00	**863E**	$469
77-II	$155.00	**867E**	$659
79/29-II	$175.00		
87	$287.00		

SPECIALTY

- Sound meter $169.95
- EMF Tester $69.95
- Conductivity $169.95
- Thermometer $69.95-$89.95
- Humid./Temp meter $169.95
- Press. meter $299.95
- Electr. scale $89.95
- Watt Meter $129.95
- High Voltgae Probe $59.95
- pH Meter $79.95
- Light Meter $80-$90
- Light Adapter $49.95
- Anemometer $179.95
- Anemometer adapter (And More) $89.95

OSCILLOSCOPE

Dual Trace, Component Test, 6" CRT, X-Y Operation, TV Sync, CH2 Output, Graticule Illum, 2 Probes(x1;x10)



- PS-200 20 MHz Dual Trace $339.95
- PS-205 20 MHz Dual w/ Delay Sweep $429.95
- PS-400 40 MHz Dual Trace $494.95
- PS-405 40 MHz Dual w/ Delay Sweep $569.95
- PS-605 60 MHz Dual w/ Delay Sweep $769.95
- PS-1000 100MHz Dual Trace $999.95

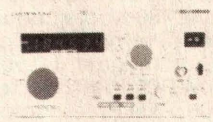
Digital Scope:

- DS-303 30MHz Digital, 20 Samples/sec $849.95
- DS-303P RS-232 interface, 30Mhz $1,049.95

Scope Probe:

HP-9060 (60MHz) $15, HP-9150 (150MHz) $22, HP-9250 (250MHz)$29, HP-9258 (250MHz,100:1)$39

AUDIO/RF/FUNCT. GENERATOR



RF Generator

- **SG-4160** ($124.95) 100kHz-150MHz sinewaves in 8 ranges, 100mV at 35MHz
- **SG-4162** ($229.95): Generate same signal as SG-4160, but with int. counter (150MHz).

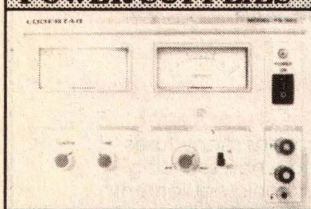
Audio Generator

- **AG-2601** ($124.95)10Hz-1MHz, 0-8Vpp sine, 0-10Vpp squarewave
- **AG-2603** ($229.95): Same as AG-2601, but with additional counter and digital display.

Function Generator

- **FG-2100A**($169.95).2Hz-2MHz,5mV-20Vpp
- **FG-2102AD** ($229.95) same as FG-2100A, but with int. counter and TTL, CMOS output.
- **FG-2103** ($329.95) *Sweep* 0.5Hz-5MHz, linear/log, VCG, GCV, and int. counter

POWER SUPPLIES



Single Output DC Power Supplies

- Short Circuit and overload protected
- Constant current, constant voltage mode
- 0.02%+2mV line regulation; 0.02%+2mV load regulate

Analog Meters Display

PS-303 ($159.00) 30V/3A
PS-305 ($219.95) 30V/5A
PS-8110 ($289.95) 60V/5A
PS-8112 ($399.95) 60V/5A
PS-1610 ($289.00) 16V/10A
PS-8107 ($399.95) 30V/10A

Digital Voltage, Analog Current

PS-8200 ($179.95) 30V/3A
PS-8201 ($239.95) 30V/5A

Digital Volt & Current Display

PS-8300 ($199.95) 30V/3A
PS-8301 ($259.95) 30V/5A

Dual Tracking

- Short Circuit & overload protected
- Constant current & constant mode
- Independent or Tracking

Dual Tracking (Analog V & I Displays)

PS-303D ($314.95) 30V/3A/30V/3A
PS-305D ($399.95) 30V/5A/30V/5A
PS-8108 ($549.95) 60V/3A/60V/3A
PS-8109 ($699.95) 60V/5A/60V/5A

Triple Output

- One fixed 5VDC, 3 Amp output
- Parallel to double current output (PS-8102 & PS-8103 only)

Triple Output (Analog displays)

PS-8102 ($399.95) 30V/3A/30V/3A
PS-8103 ($489.95) 30V/5A/30V/5A

Digital Displays

PS-8202 ($499.95) 30V/3A/30V/3A
PS-8203 ($549.95) 30V/5A/30V/5A

INSTEK® Test & Measuring Instrument

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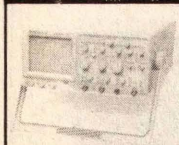
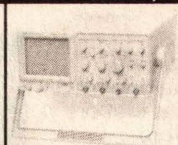
OSCILLOSCOPE

OS-653 $699.95 50MHz Triggering



- Dual CH / Delay sweep
- ALT trigger, trigger lock
- 1mV/div sen., delay line
- Zaxis input,CH1 output
- Hold off, TV syn.
- 2 probes (x1, x10)

OS-622B $399.95 20 MHz Oscilloscope



- Dual CH/X-Y operation
- 1 mV/div sensitivity
- Z-axis input,CH1 output
- TV syn., trigger level lock
- 2 probes (x1, x10)

OS-305 ($209.95) - 5 MHz One Channel
OS-310 ($324.95) - 10 MHz One channel

DC POWER SUPPLIES

Triple Output

- 2 variable out 0-30V,0-3A
- One fixed 5V,3A output
- Auto track, serial, parallel
- Const. volt, current mode
- 4 analog or 2 digital display

PC-3030 ($499.95)
PC-3030D ($549.95)

Single Output

- Const voltage, current mod
- Voltage regulation ≤0.01%
- Current regulation ≤0.2%
- PS: 2 analog or 1 digital dis
- PR: 2 analog or 2 digital dis

Analog Meters Display

PS-1830 ($209.95) 18V/3A
PS-1850 ($219.95) 18V/5A

PS-3030 ($224.95) 30V/3A
PS-6010 ($209.95)60V/10A

PR-3060 ($314.95)30V/6A
PR-6030 ($314.95)60V/3A

Digital Meters Display

PS-1830D($219.95)18V/3A
PS-1850D($244.95)18V/5A
PS-3030D($254.95)30V/3A
PR-6030D($399.95)60V/3A

Programmable

- High stability, low drift
- One fixed 5V,3A output
- 100point program(PPS ser)
- 50point program(PPT ser.)
- Auto serial/parall.(PPT ser)
- Auto track (PPT series), IEEE-488.2 and SCPI compatible command set (optional)

PPS-1860G ($1,099.95)
PPS-3635G ($1,099.95)

PPS-6020G ($1,099.95)
PPT-1830G ($1,399.95)
PPT-3615G ($1,399.95)

FUNCTION GENERATOR

FG-8015G($189.95)Sweep
- 0.02Hz-2Mhz,no counter
- Sine/Squ/Tri/pulse/Ramp

FG-8016G ($239.95)
- 0.02Hz-2MHz w/ counter
- Pulse, function generator

FG-8017G($249.95)Sweep
- Sine/Tri/Squ/TTL/CMOS
- 0.02Hz-2Mhz, FM mod.

FG-8019 ($399.95) Sweep
- 0.02Hz-2MHz w/counter
- INT/EXT AM/FM mod

FG-8019 ($209.95)
- 0.02Hz-2MHz w/counter

FG-8050 ($499.95) Sweep
- 0.05Hz-5MHz w/counter
- INT/EXT AM/FM mod

FG-830 ($1,499.95) 30MHz Synthesized Function Gen.
- Output: sine, tri., square, sync out, arb. waveform
- 20mHz Freq. resolution
- Linear/log sweep
- Arbitrary modulation
- RS232; IEEE-488(option)

BENCHTOP DMM

DM-8034($179.95) 3½ dgt
- AC/DV(V,A),C,Ω,diode
- 1000V, 20A, 0.5% accu.

DM-8040($339.95) 3½ dgt
- ACV to 50kHz, true rms

DM-8055($649.95) 5½ dgt
- 0.006% basic accuracy
- 1uV,1mΩ,1nA resolution
- dBm,auto,REL, min/max

DM-8055G($889.95)GPIB
- Same funct. as DM-8055

Frequency Counters

FC-8131 ($469.95)1.3GHz
FC-8270 ($629.95)2.7GHz
UC-2010G ($294.95)

Programmable Electronic Load (PEL-300)

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- Over voltage, over current, over power protection
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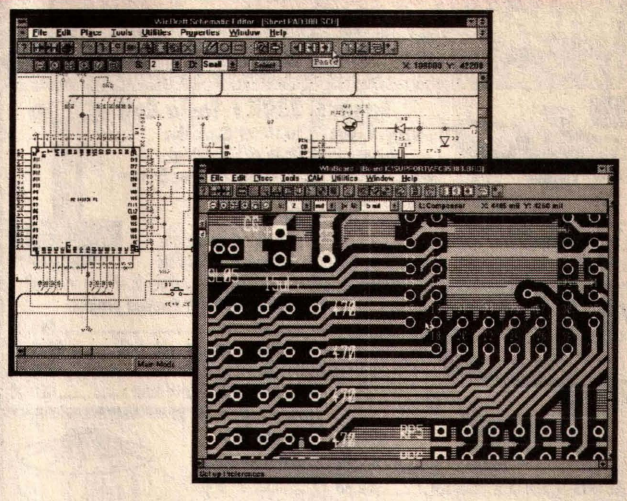

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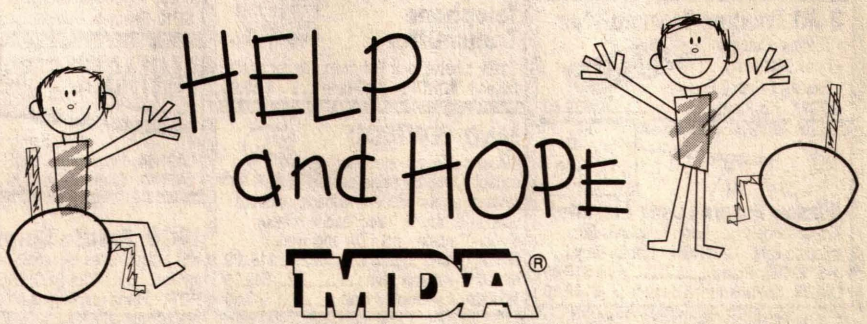

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3 Mi Telephone Xmitter

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FireBall Gun

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FIREBALL Plans (dangerous product) . **$10.00**

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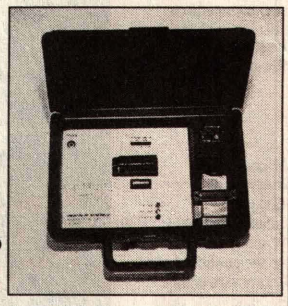

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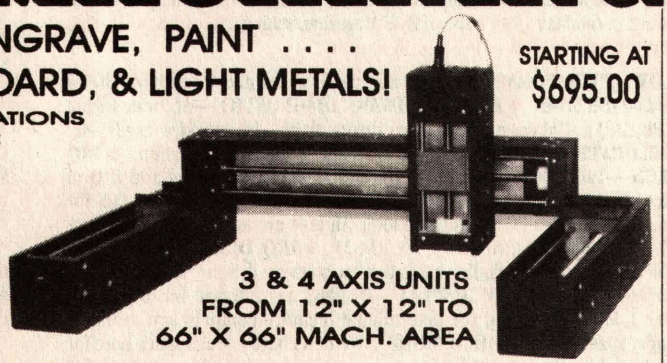

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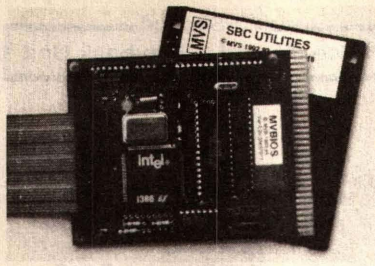

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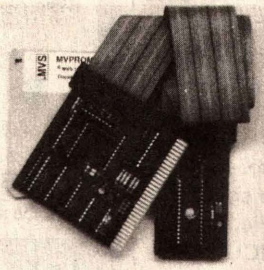

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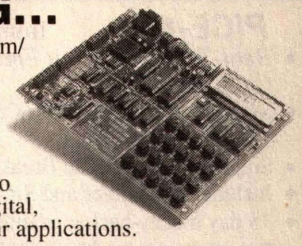

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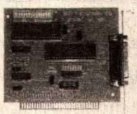

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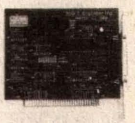

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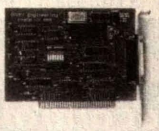

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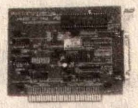

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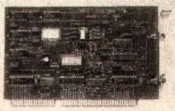

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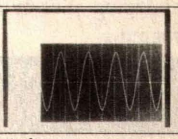

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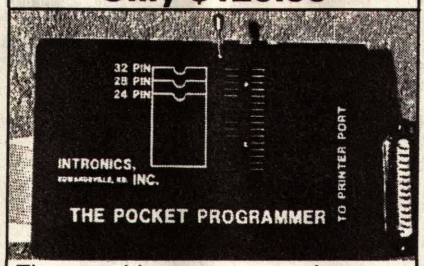

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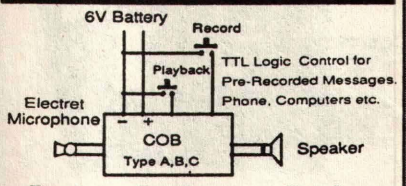

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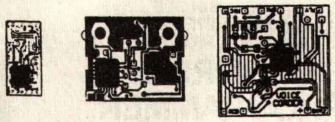

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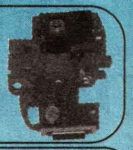

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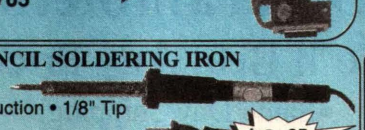

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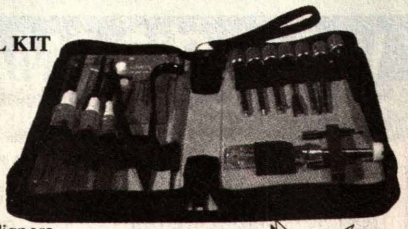

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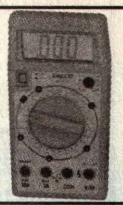

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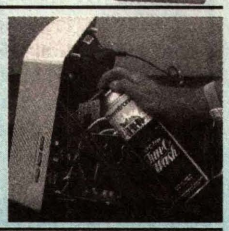

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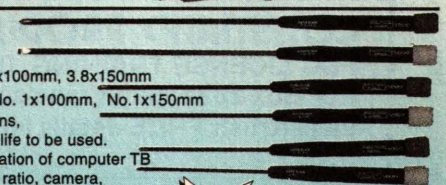

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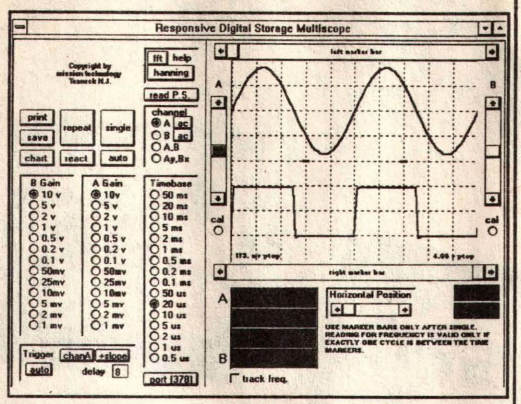

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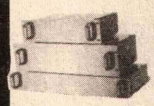

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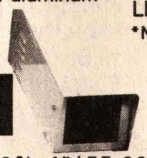

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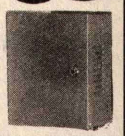

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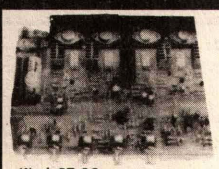

Kit:$ 67.92
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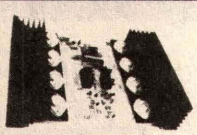
AF-3 ▲▲▲ 300W MOSFET High Power Mono Amp. (7 lbs.)



Kit:$ 165.00 Asmb.$ 195.00

Power Output: 300W into 4 ohms RMS. 200W into 8 ohms RMS. Frequency Response: 10HZ-20KHZ. THD: <0.03%. Signal to noise ratio: 91dB. Input Sensitivity & Impedance at 1KHZ, 1V 47K. Load Impedance 4-16 ohms. Power Requirement: ±55 to ±65VDC 8A. Suggested Mark V model 009 Transformer. Capacitor 8,200uf 100V model 020. Recommended Cabinet LG-1925 for each channel.

TA-388 ▲▲▲ Class A FET Dynamic Buffer Stereo Pre-Amp (1 lb.)

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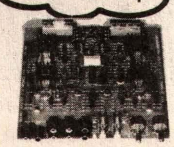

Kit:$64.00 Asmb.$ 80.00

Frequency Response (at rated output): Overall 10HZ-100KHZ +0.5dB-1dB. THD: Overall <0.007% at or below rated output level. Channel Separation (at rated output 1KHZ): Overall better than 70dB. Hum & Noise: Overall better than 90dB. Input Sensitivity (1KHZ for rated output): 300-600mV. Maximum Output Level: Pre-Amp output 1.8V (0.1% THD). Power Requirement: 30V X 2 AC 500mA. Suggested Mark V model 010 transformer.

SM-100 ▲▲▲ 150 MHZ 8 Digit Frequency Counter (2 lbs.)

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Frequency Range: 10HZ-150MHZ. Gate Time: 0.01s, 0.1s, 1s, 10s. Input Sensitivity: KHZ range 10HZ-10MHZ 20mV(min.). MHZ range 1MHZ-120MHZ 20mV(min.), 120MHZ-150MHZ 35mV (min.), 150MHZ-200MHZ 40mV(typical). Time Base: 10MHZ crystal, ±10 ppm. Input Impedance: 1M ohm. Response Time: 0.2s. Resolution: 0.1 HZ: 10s gate time, 1HZ: 1s gate time, 10HZ: 0.1s gate time, 100 HZ: 0.01s gate time. Hold the last input signal. Reset counter to 0. DC 9V power adapter not included.

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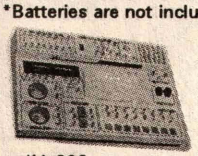
KA-904

KA-906



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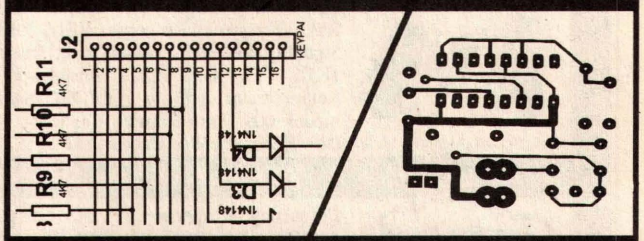

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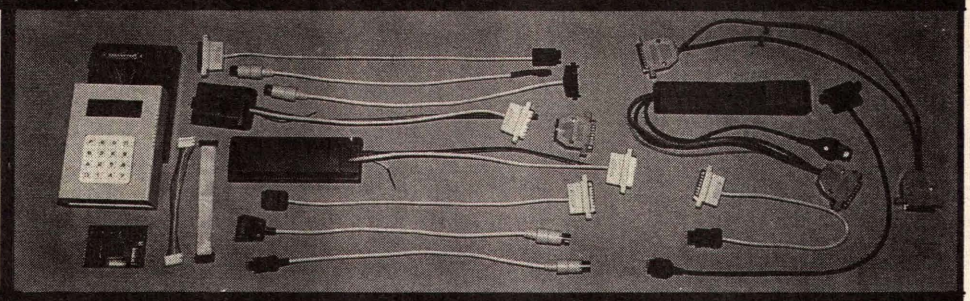

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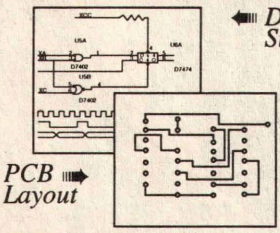

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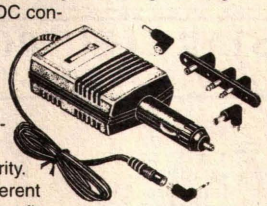

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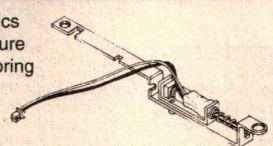

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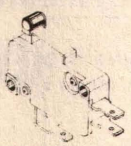

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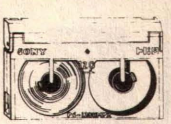

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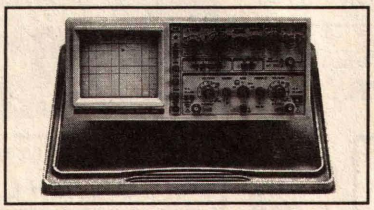

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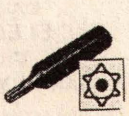

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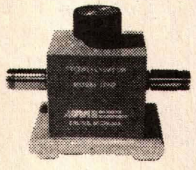

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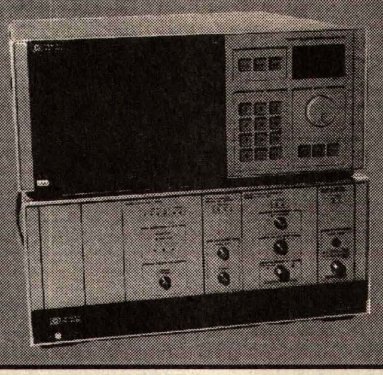

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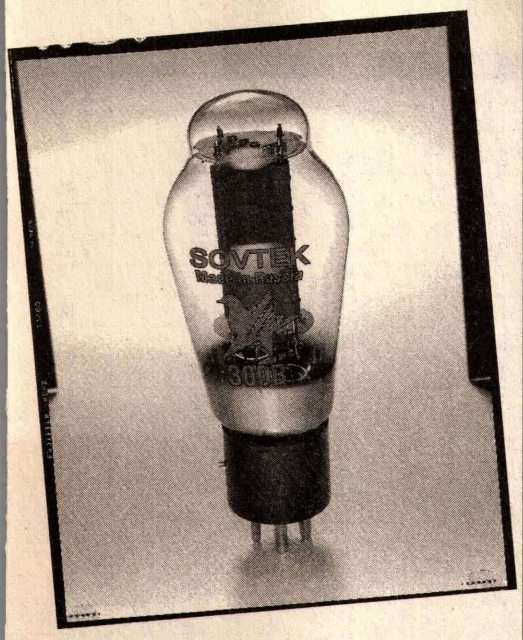

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807	$6.90	$5.90	$4.90
811	7.90	6.20	5.30
812	12.00	10.75	9.70
813	25.00	23.00	21.50
845	27.00	25.50	22.00
2A3	14.90	13.50	12.70
211	23.90	21.90	19.50
5U4G	4.90	4.20	3.90
5AR4/GZ34	7.90	6.90	5.90
12AT7	3.70	3.40	3.25
12AX7A	2.90	2.20	1.95
12AU7	3.90	3.50	2.90
KT88	14.90	13.50	11.90
KT100	21.00	19.50	17.00

SVETLANA

	1	10	20+
EL34	$9.70	$8.90	$7.80
SV6550C	16.90	14.90	13.80
811-10SV	25.90	21.80	19.50
6L6GC	10.80	9.70	8.90
SV572-3	57.00	49.00	44.00
SV572-10	57.00	49.00	44.00
SV572-30	57.00	49.00	44.00
SV572-160	57.00	49.00	44.00

STANDARD MATCHING
available on most octal power tubes. *60¢ extra per tube.* **Pairs, Quads, Sextets.**

PLATINUM MATCHING
available with 24 hour test and burn-in, ensuring premium match.
$2.00 extra per tube.

300B "Dual 2 point matching" premium pairs
$3.00 extra per tube.

MasterCard
VISA

TESLA-CZECHOSLOVAKIA

	1	10	20+
6L6G JJ	$10.80	$9.70	$8.90
KT88	33.90	30.90	28.50
KT88BL *sky blue glass*	43.00	37.00	33.90
E34L	8.90	7.90	5.90
E34BL *sky blue glass*	15.90	14.80	12.90
E34RL *light rose red glass*	12.50	11.70	10.90
ECC83/12AX7	5.90	5.60	5.25
EL84/6BQ5	5.90	5.20	4.65

EI - YUGOSLAVIA

	1	10	20+
6CA7 "big bulb"	$11.50	$10.50	$8.90
6CG7/6FQ7	6.50	5.80	5.20
12AT7/ECC81	4.90	3.90	3.60
12AU7/ECC82	4.60	3.80	3.20
12AX7/ECC83	4.50	3.60	2.90
12BH7	7.90	6.90	5.90
12DW7/7247	7.90	6.90	5.90
EL34	7.50	6.50	5.50
EL509/6KG6	11.90	10.90	9.90
KT90	28.50	25.80	23.25
PL519/40KG6	11.90	10.90	9.90

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USA MILITARY JAN TUBES

NEW - ORIGINAL BOXES

	1	10	25	50	100	500	1000+
0C3W JAN RAYTHEON	$4.50	$3.90	$3.20	$2.90	$2.60	$	$
35W4 JAN GE	2.90	2.50	2.20	1.90	1.60		
5Y3WGTA JAN PHILIPS	5.50	4.50	3.90	3.40	2.90		
6AK6 JAN GE	1.50	1.10	.90	.80	.70	.55	.45
6AN5WA JAN PHILIPS	2.75	2.20	1.80	1.40	.90	.80	.70
6AS7GA JAN GE	6.90	5.50	4.90	3.90	2.90	2.65	2.45
6AU6WC JAN PHILIPS	4.50	2.90	2.50	1.90	1.60		
6AW8 JAN	3.50	2.75	2.25	1.90	1.25	.90	.80
6B4G JAN SYLVANIA	24.90	21.90	19.90	18.90	17.90		
6BJ7 JAN	3.50	2.75	2.25	1.90	1.50	1.25	
6BQ7A JAN GE	2.90	1.60	1.35	1.15	.95	.80	.70
6C4WA JAN PHILIPS	3.50	2.90	2.20	1.80	1.10	.90	.75
6CX8 JAN GE	3.15	2.50	2.15	1.85	1.70		
6DJ8 JAN PHILIPS	5.90	4.90	4.20	3.90	3.50		
6EA8 JAN PHILIPS	3.50	2.00	1.60	1.35	.95	.70	.55
6EJ7 JAN PHILIPS	2.90	1.90	1.40	1.00	.75	.60	
6H6 JAN GE	1.50	.90	.80	.60	.40	.30	.25
6J5WGT JAN PHILIPS	5.90	4.90	4.25				
6K7 JAN GE	2.90	1.90	1.40	1.25	1.00		
6L6GC JAN PHILIPS	22.50	19.90	18.50				
6L6WGB JAN PHILIPS	13.90	11.90	10.90	9.90	8.90	7.90	7.50
6SL7WGT JAN PHILIPS	8.90	6.90	5.90				
6SN7WGTA JAN PHILIPS	8.90	6.90	5.90	5.50	5.40		
6U8A JAN PHILIPS	3.40	2.70	1.90	1.40	.95	.80	.70
6V6 JAN PHILIPS	14.90	12.20	10.80	9.70	8.90	8.40	7.90
6X5WGT JAN PHILIPS	5.90	4.80	3.90				
6Y6GT JAN RAYTHEON	3.90	2.90	2.30	1.95	1.50		
12AT7WC JAN GE	6.50	5.50	4.90	4.40	3.90		
12AT7WC JAN PHILIPS	5.50	4.70	4.20	3.60	2.40	2.05	1.85
12AU6 JAN PHILIPS	3.90	2.50	1.60	1.25	.95		
12AX7WA JAN GE	9.65	7.70	6.50	5.90	5.40	4.90	4.50
12AX7WA JAN PHILIPS	9.65	7.70	6.50	5.90	5.40	4.90	4.50
12B4A JAN GE	3.90	3.50	2.70	2.30	2.10		
12SG7 JAN RCA	3.90	2.90	2.20	1.90	1.70		
12SH7 JAN GE	3.90	2.90	2.20	1.90	1.70		
829B JAN CETRON	8.90	7.90	6.90	6.40	5.90	5.80	5.70
5750 JAN GE	3.90	2.25	1.70	1.40	1.30		
5751 JAN GE	5.90	5.40	4.90	4.40	3.60	3.20	2.90
5814A JAN PHILIPS	3.75	3.00	2.75	2.50	2.20	2.00	1.90
6072A JAN GE = MIL 12AY7	8.90	7.70	6.50	5.90	5.40		
6188 JAN PHIL = MIL 6SL7	11.15	8.90	7.90	6.40	5.90	5.60	
6189W JAN PHILIPS	3.75	3.00	2.75	2.50	2.20	2.00	1.90
6550A JAN GE	42.00	34.50	***Pristine 1985 Military Stocks***				
6922 JAN PHILIPS	6.90	5.90	4.90	3.90			
7199 JAN PHILIPS	24.50	20.90	19.80	18.80	17.70		
7581A JAN PHILIPS = MIL 6L6GC	21.50	19.50	18.20	16.50	15.75	14.75	14.35

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tubes & sockets

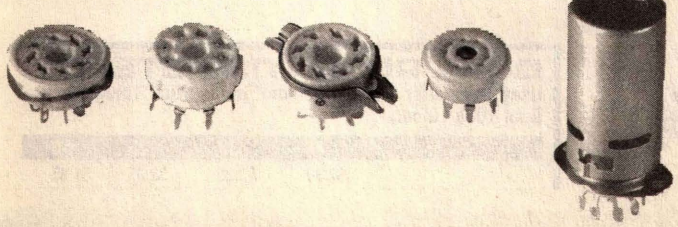
ODD BALL TUBES

0A2	$4.90	6BL8	4.90	6X8	4.90	5961 JAN NATIONAL	3.90
0A3	4.90	6BM8	4.50	7F7 JAN SYLVANIA	3.50	5976/DOD 001 JAN RAY	3.60
0A5 JAN CETRON	1.90	6C10	10.90	7F8 JAN SYLVANIA	1.75	6080	5.90
0D3W JAN RAYTHEON	3.50	6C19 PI (6C33 DRIVER)	6.90	12AU7 RFT	8.90	6082WB JAN RAYTHEON	5.90
1X2C JAN PHIL/GE	.15	6C33C-B SOVTEK	34.90	12AV7	5.90	6088 JAN RAYTHEON	.60
2B22 JAN GE	4.00	6C41C	16.90	12AY7/6072A	8.90	6186W JAN PHILIPS	1.75
2C42 JAN GE	9.00	6CA4	7.90	12AZ7	5.90	6206 JAN RAYTHEON	3.25
2G21 JAN RAYTHEON	3.30	6CB6 JAN GE	.80	12BH7A GE	15.50	6264A JAN RCA	1.30
2K25	25.00	6CH8 JAN RCA	1.50	12BY7	10.90	6267/EF86	6.90
2K45 RAYTHEON	6.90	6CW4	11.90	12FQ8	11.90	6418 JAN RAYTHEON	.95
3B22 JAN CETRON	10.50	6CW5	3.90	12SJ7 JAN	4.90	6844A JAN	9.50
3B24WB JAN CETRON	5.50	6C8G JAN RCA	1.50	14R7 JAN SYLVANIA	.60	6888 PHILIPS	1.20
3E29 JAN CETRON	5.75	6DR7	6.50	50C5	5.90	6973	14.90
4CS 250H EMAC	39.50	6E5	11.90	884 JAN SYLVANIA	1.90	7310	5.90
5A6 JAN TUNG/RAY	1.20	6FH8	17.90	5642 JAN PHILIPS	.95	7984 JAN	2.50
5C22	59.00	6GW8/ECL86	7.90	5656 JAN RAYTHEON	3.90	807 SOVTEK	9.90
5R4	6.90	6J7	8.50	5670W JAN GE	.60	8421 JAN NATIONAL	3.00
5V4GT	3.25	6JE6/6LQ6 USA	45.00	5676 JAN RAYTH	.80	8951 JAN ITT	10.00
6AG7 JAN GE	.85	6K11	8.90	5691 JAN *BROWN BASE*	21.90	154-0517-05 TEKTR	45.00
6AL5	3.50	6K6	7.50	5702 WB JAN RAYTH	.50	154-0672-05 TEKTR	20.00
6AN8	5.90	6KG6/EL509/6Pi45C	15.50	5703WB JAN RAYTH	.50	CAGX3JP1 JAN	10.00
6AQ5A	5.90	6N7	5.25	5719 JAN PHILIPS	1.10	CK7995 JAN RAYTH	.90
6AQ8	7.90	6SC7	9.90	5744WB JAN RAYTH	.50	EF50	.30
6AX5	5.50	6SF7 JAN RCA	3.60	5749	3.50	*ECC88 MULLARD GOLD PINS*	24.90
6BA6	3.50	6SG7	4.50	5784WB JAN RAYTH	.50	*E182CC MULLARD*	15.90
6BC5/6CE5 PHILIPS	.80	6SK7	4.90	5787WA JAN RAYTH	.50	MA-6230 MAGNETRON	12.00
6BE6	4.90	6SQ7	4.50	5840 JAN PHILIPS	.50	NL5561	5.50
6BH6	4.90	6U10	7.50	5842Q JAN RAYTH	4.90		
6BK11 Ampeg	8.90	6X4	5.90	5879	8.90		

TUBE SOCKETS

CERAMIC CHASSIS MOUNT	1	25	50	100+
8 pin octal w/mounting bracket	$1.50	$1.10	$.95	$.85
8 pin octal w/snap ring for mounting	1.50	1.10	.95	.85
9 pin miniature (12AX7 type) w/shield	1.50	1.10	.95	.85
9 pin miniature plastic (Fender® pre-amp)	.90	.70	.60	.55
Shield for above 9 Pin plastic	.60	.45	.35	.30
4 pin for 300B, 811 and 2A3	3.00	2.25	1.95	1.80
4 pin for 211 and 845	5.50	4.50	4.10	3.85
5 pin for 807	3.75	3.10	2.85	2.50
Ceramic cap for 807	2.00	1.30	1.00	.85
7 pin for 6C33C-B, 829B and 3E29	3.75	3.30	2.90	2.60

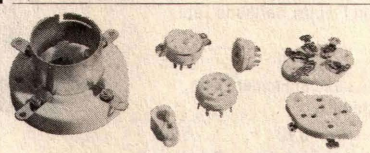
CERAMIC PC MOUNT	1	25	50	100+
8 pin octal	$1.15	$.85	$.75	$.65
9 pin miniature	1.30	.85	.75	.65
7 pin miniature for 6AU6	1.25	.80	.70	.60
12 pin Compactron	2.90	2.40	2.10	1.90



GOLD PLATED TUBE SOCKETS

CERAMIC CHASSIS MOUNT	1	25	50	100+
8 pin octal w/mounting bracket	$2.60	$1.95	$1.70	$1.50
9 pin miniature (12AX7 type) w/bracket	2.80	2.05	1.75	1.60
4 pin for 300B, 811 and 2A3	5.55	4.20	3.60	3.35
4 pin for 211 and 845	10.20	8.35	7.60	7.15
5 pin for 807	6.95	5.75	5.30	4.65
Ceramic cap for 807	3.70	2.40	1.85	1.60

CERAMIC PC MOUNT	1	25	50	100+
8 pin octal	$2.15	$1.60	$1.40	$1.20
9 pin miniature	2.40	1.60	1.40	1.20



SPRING RETAINERS

Holds 5881 tube firmly in socket. Useful for "upside down" tubes. Design similar to clamps used by Marshall™.

1	12	25+
$1.25	$.85	$.78

SOLID STATE RECTIFIER

Direct plug-in replacement for all 5Y3, 5U4 and 5AR4 types.

1	10	25+
$5.90	$5.50	$4.90

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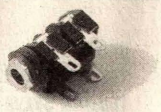
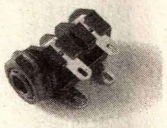
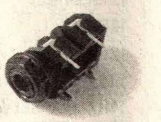
jacks, switches & pots

JACKS

	1	10	25	100+
BJ101 Mono input jack, 4 solder terminals, switched. Vintage type with metal ferrule. Used in British amps such as Marshall™, Hiwatt, Orange & Sound City.	$1.40	$1.30	$1.10	$1.07
BJ102 Mono input jack, 4 solder terminals, switched. Modern Marshall™ type with black plastic nut.	1.05	.90	.60	.57
BJ103 Mono input jack, 4 PC board terminals, switched. Modern Marshall™ type. Used in Marshall™, Ampeg, Crate & many others. Replacement for Marshall™ JCM 900 cabinets.	1.05	.90	.60	.57
BJ104 Stereo Input jack, 6 PC board terminals, switched. Modern Marshall™ type. Used in many PA & recording consoles and Marshall™ Bass heads as well as "rack" units.	1.15	1.00	.90	.87
BJ105 Same as BJ104 but with 6 solder lugs.	1.15	1.00	.90	.87
11 SWITCHCRAFT 1/4" female. Open circuit. Can be used as replacement in Fender® external speaker/guitar output/ effects pedals.	.95	.85	.76	.69
12A SWITCHCRAFT 1/4" female. Shorting type. Can replace Fender® input jack.	1.20	1.10	1.00	.85
L12A SWITCHCRAFT 1/4" female. Same as 12A but with longer thread.	1.25	1.15	1.05	.86

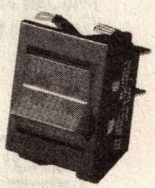


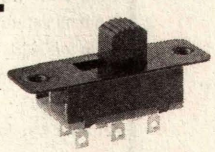


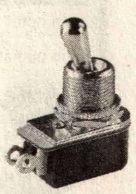


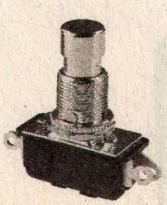
SWITCHES

	1	10	25+
SWLJCM Lighted power switch used on Marshall™ "JCM" series & others.	$4.75	$4.25	$3.95
SWJCM Solid black standby rocker switch for "JCM" series & others.	2.95	2.70	2.45
VTL5C1 Optoisolator for channel switching circuits as in Fender®, Boogie, etc.	5.20	4.90	4.75
SWSLD Standard DPDT (On On) slide switch. Can replace bright switch in Fender®.	1.25	.95	.75
SW110-63 Carling SPST toggle - Power and standby switches that can be used as replacement in Fenders®.	2.25	1.95	1.85
SW112-63 Carling SPDT toggle - Perfect replacement for Fender® ground switch.	2.55	2.30	2.10
SW112-P Carling SPDT footswitch - Used in Electro Harmonix, etc. effects pedals.	4.95	4.80	4.65
SW110-P Carling SPST footswitch - Can be used in Fender®, etc. reverb/trem/channel switching pedals.	2.85	2.65	2.55
SW316-PP Carling DPDT footswitch - Used in many effects and switching units.	7.30	6.70	5.90
SWMPXTG Original Marshall™ Plexi toggle switch.	7.90	7.45	7.20
SWMPXNT Original Marshall™ Chrome nut for above.	1.20	1.10	1.00
SWMSHV Original Marshall™ JMP style voltage selector switch.	7.80		
SWMSHI Original Marshall™ New style output impedence selector switch.	7.90		

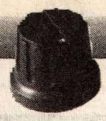








CONTROL KNOBS



Small black knob with brass insert. .78" dia .61" height dot indicator. Perfect fit for potentiometers we offer.

1	10	25	50+
$1.00	$.85	$.75	$.55

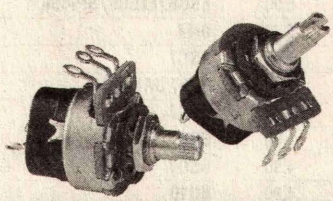
ORIGINAL MARSHALL™ CONTROL KNOBS

Set screw style (package of 8 pcs)	$1.19ea knob
Push on style (package of 8 pcs)	1.19ea knob

CTS POTENTIOMETERS

Identical to pots used in most American amps. 1/2 watt, 3/8" mounting, 1/4" splined shaft for set screw or push-on knobs. Smooth action - top quality. 10k Log, 50k Rev. Log, 100k Linear, 250k Log, 500k Log, 1M Log, 3M Rev. Log.

1	10	25	50+
$2.50	$1.70	$1.40	$1.25

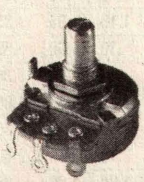


CTS POTENTIOMETERS WITH PUSH/PULL SWITCH

NEW!

Most commonly used in American amps. 1/2 watt, 3/8" mounting, 1/4" knurled split aluminum. Smooth action - top quality. 10k Log, and 1M Log. Switch is single pole.

1	10	25	50+
$4.50	$3.90	$3.65	$3.40



ALPHA POTENTIOMETERS

Ultra high quality dampened rotational movement provides very smooth feel throughout turn. Full size 1/4" dia x 5/8" len solid shaft. Available in the following values:
Linear - 5k, 10k, 25k, 100k, 250k.
Log - 500k, 1meg.

$1.00	$.85	$.75	$.65

DUAL POTENTIOMETERS

Used in popular "master volume" mods. Dual 1meg Log or Dual 100k Linear.

1	10	25	50+
$2.90	$2.25	$2.05	$1.95

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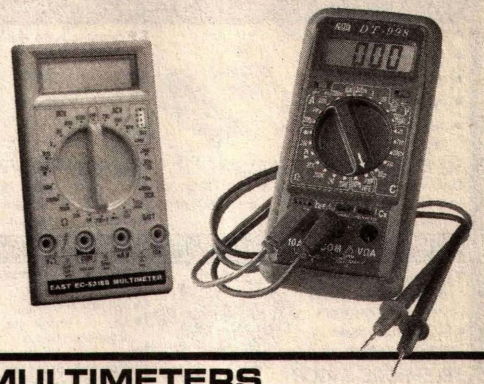
parts

CAIG LABORATORIES, INC.

CAIG CHEMICALS

	1	10+
DEOXiT! D5 spray. Contact cleaner/deoxidizer. Most popular cleaner available. Use with below P5 for best results. 5 oz.	**$7.85**	**$7.25**
DEOXiT! DP5S-6 spray. Contact cleaner/deoxidizer. Pump spray version. No shipping or storage restrictions. Environmentally-friendly 5 oz.	**10.90**	**9.50**
PRESERVEiT! P5 spray. Contact preservitive/lubricant. Use after above D5 to greatly extend contact integrity. Protects against oxidation and wear. 5 oz.	**7.85**	**7.25**
CAIKLEEN TRP DG7 spray. Degreaser/cleaner/flux remover. Clean contaminants from sockets, switches, PC boards, etc. Natural formula safe on most plastics. Use before above D5 for best results. 5 oz.	**6.50**	**5.90**
PROGOLD G5S-6 spray. Absolute best contact cleaner for gold and other base metal contacts. Conditions, seals and protects gold audio connectors, computer cards, tube sockets, video connectors, etc. 5 oz.	**12.85**	**12.25**
PROGOLD K-G100P pen. Same as above but in 100% precision pen applicator. No waste, no mess. Great for tube pins, card edge connectors, relays, audio/video connectors, etc. Applicator works like "magic marker".	**14.95**	**14.20**
DUSTALL DT3PS-10 spray. Precision air duster. Quickly and safely removes dust, lint and particles from electronic equipment. 10oz.	**10.50**	**9.90**
FREEZEALL FZ7PS-10 spray. Locates intermittents, cools components to -54C. 10oz.	**10.50**	**9.90**
CaiLube MCL *MCL5S-H6 spray.* Precision lubricant specifically formulated to improve conductivity and lubricate conductive plastic and carbon compound faders, switches and other similar components. 5 oz.	**9.50**	**8.50**



MULTIMETERS

	1pcs	3pcs
COMPACT DMM - Light weight - durable case. 3-1/2 digit LCD. 24 range. AC/DC 10A. Battery check. Diode check. Transistor check. AC 750V, DC 1000V. Complete with probes, 9V battery and operating manual.	**$14.95**	**$14.25**
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JEWELS REPLACEMENT FOR FENDER® AMPS.

NEW! Avalible in red, green or amber.

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NEW! Replacement for pilot light bulb in Fenders®

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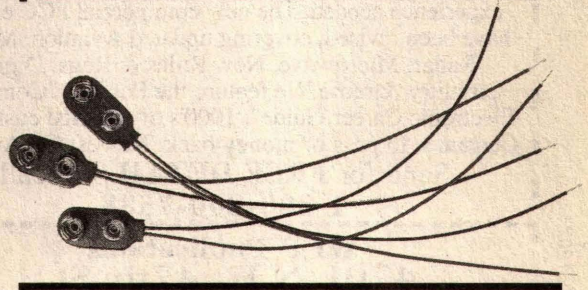
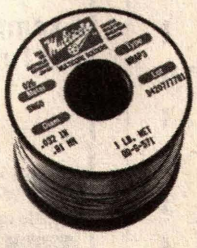
# 47 BULB	$.90	$.25	$.20





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BATSNAP	$.25	$.19	$.15	$.14

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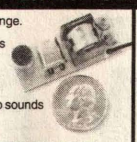
- Miniature photo battery mounts right on circuit board.
- Transmits at 143 MHz.
- Amazing audio sensitivity, picks up sounds at the level of a whisper.



CRYSTAL CONTROLLED FM TRANSMITTER
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- Transmits at 143 MHz.
- Up to 1 mile range.
- Works with most any scanner type receiver.

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- Dial your phone from anywhere and listen to the sounds inside your home.
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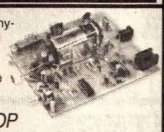

TELEPHONE SNOOP
The latest in home or office security. Call home from anywhere, enter a two digit security code, and hear the sounds in your home. Automatically turns on without ringing the phone, verifies code, then activates for one and a half minutes.
XPS-CASE KIT $14.95
XPS1000 C KIT $55.95

- Smallest Phone transmitter anywhere!
- Tunes 88-108 MHz.
- Up to 1/4 mile range.
- Attach to phone line anywhere in house.
- No batterie required, powered by phone line.

SUPER-MINIATURE PHONE TRANSMITTER
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- Covers 1 to 2,000MHz.
- Adjustable sensitivity.
- Audio jack for privacy ear phone.

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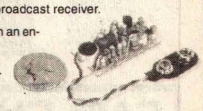

MINIATURE FM TRANSMITTER
The XFM100 has a super sensitive microphone and is capable of picking up sounds at the level of a whisper and transmitting them to any FM broadcast receiver.
XFM100 C Kit $21.95

- Will analyze live voice best, but will work over the phone, and even from recordings
- Has built in microphone.
- Easy to use LED output display.
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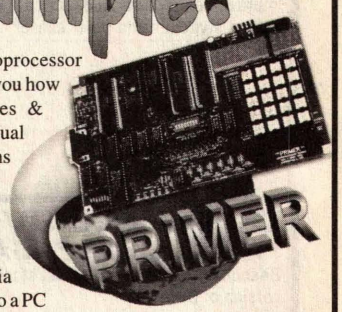

The PRIMER 8085 Based Microprocessor Training and Control System shows you how to program by example. Examples & exercises in the Self Instruction manual take you from writing simple programs to controlling motors. Start out in Machine language, then move on to Assembler, & then continue on with optional C, Basic, or Forth Compilers. This trainer can be used stand alone via the keypad and display or connected to a PC with the optional upgrade ($49.95). The Upgrade includes: an RS232 serial port & cable, 32K of battery backed RAM, & Assembler/Terminal software.

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- Bus Interfacing an 8255 PPI (new)
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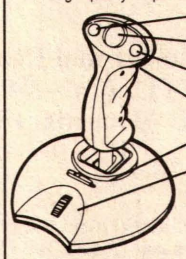

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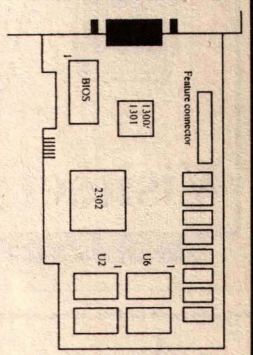

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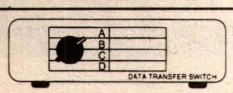

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DB25 Male to Mini Centronic 36
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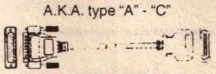

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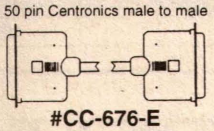
50 pin Centronics male to male



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DB25 Null Modem Adaptor
for serial printer and plotters
male to female
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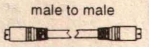

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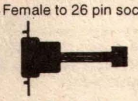

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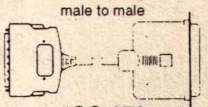

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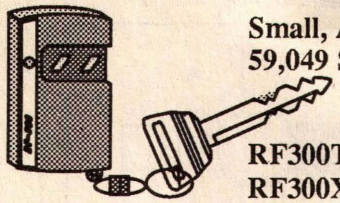

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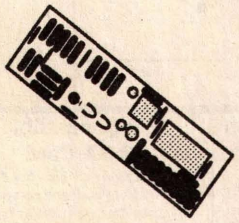

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Input: 8–24 vdc Output: Gated CMOS Momentary and Latching Lines

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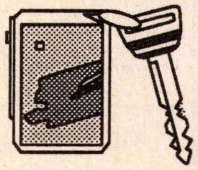

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Doug Pettit - LuRay Electronics - LuRay VA 703-743-5400
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Randy Whitehead - Service West - Salt Lake City UT 801-262-4069
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Bill Warren CET/CSM - Warrens Audio & Video Knoxville TN - 234-546- 1128
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Keith Sahs - J & M Electronics - Omaha NE 402-291-7100
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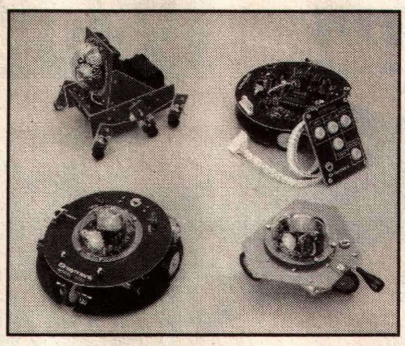

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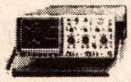

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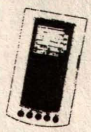

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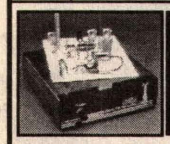
Synthesized FM Stereo Transmitter

Microprocessor controlled for easy freq programming using DIP switches, no drift, your signal is rock solid all the time - just like the commercial stations. Audio quality is excellent, connect to the line output of any CD player, tape deck or mike mixer and you're on-the-air. Foreign buyers will appreciate the high power output capability of the FM-25; many Caribbean folks use a single FM-25 to cover the whole island! New, improved, clean and hum-free runs on either 12 VDC or 120 VAC. Kit comes complete with case set, whip antenna, 120 VAC power adapter - easy one evening assembly.

FM-25, Synthesized FM Stereo Transmitter Kit $129.95



Tunable FM Stereo Transmitter

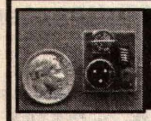
A lower cost alternative to our high performance transmitters. Offers great value, tunable over the 88-108 MHz FM broadcast band, plenty of power and our manual goes into great detail outlining aspects of antennas, transmitting range and the FCC rules and regulations. Connects to any cassette deck, CD player or mixer and you're on-the-air, you'll be amazed at the exceptional audio quality! Runs on internal 9V battery or external power from 5 to 15 VDC, or optional 120 VAC adapter. Add our matching case and whip antenna set for a nice finished look.

FM-10A, Tunable FM Stereo Transmitter Kit $34.95
CFM, Matching Case and Antenna Set. $14.95

RF Power Booster Amplifier

Add some serious muscle to your signal, boost power up to 1 watt over a frequency range of 100 KHz to over 1000 MHz! Use as a lab amp for signal generators, plus many foreign users employ the LPA-1 to boost the power of their FM Stereo transmitters, providing radio service through an entire town. Power required: 12 to 15 volts DC at 250mA, gain of 38dB at 10 MHz, 10 dB at 1000 MHz. For a neat, professionally finished look, add the optional matching case set.

LPA-1, Power Booster Amplifier Kit $39.95
CLPA, Matching Case Set for LPA-1 Kit $14.95
LPA-1WT, Fully Wired LPA-1 with Case $99.95

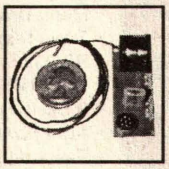


Micro FM Wireless Mike

World's smallest FM transmitter. Size of a sugar cube! Uses SMT (Surface Mount Technology) devices and mini electret condenser microphone, even the battery is included. We give you two complete sets of SMT parts to allow for any errors or mishaps-build it carefully and you've got extra SMT parts to build another! Audio quality and pick-up is unbelievable, transmission range up to 300 feet, tunable to anywhere in standard FM band 88 to108 MHz. 7/8"w x 3/8"h x 3/4"h.

FM-5 Micro FM Wireless Mike Kit $19.95

Crystal Controlled Wireless Mike



Super stable, drift free, not affected by temperature, metal or your body! Frequency is set by a crystal in the 2 meter Ham band of 146.535 MHz, easily picked up on any scanner radio or 2 meter rig. Changing the crystal to put frequency anywhere in the 140 to 160 MHz range-crystals cost only five or six dollars. Sensitive electret condensor mike picks up whispers anywhere in a room and transmit up to 1/4 mile. Powered by 3 volt Lithium or pair of watch batteries which are included. Uses the latest in SMT surface mount parts and we even include a few extras in case you sneeze and loose a part!

FM-6, Crystal Controlled FM Wireless Mike Kit $39.95
FM-6WT Fully Wired FM-6 ..... $69.95

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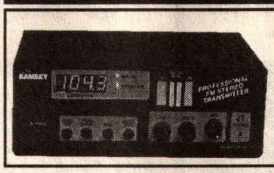
Super Pro FM Stereo Radio Transmitter



A truly professional frequency synthesized FM Stereo transmitter station in one easy to use, handsome cabinet. Most radio stations require a whole equipment rack to hold all the features we've packed into the FM-100. Set frequency easily with the Up/Down freq buttons and the big LED digital display. Plus there's input low pass filtering that gives great sound no matter what the source (no more squeals or swishing sounds from cheap CD player inputs!) Peak limiters for maximum 'punch' in your audio - without over modulation, LED bargraph meters for easy setting of audio levels and a built-in mixer with mike and line level inputs. Churches, drive-ins, schools and colleges find the FM-100 to be the answer to their transmitting needs, you will too. No one offers all these features at this price! Kit includes sharp looking metal cabinet, whip antenna and 120 volt AC adapter. Also runs on 12 volts DC.

We also offer a high power export version of the FM-100 that's fully assembled with one watt of RF power, for miles of program coverage. The export version can only be shipped outside the USA, or within the US if accompanied by a signed statement that the unit will be exported.

FM-100, Professional FM Stereo Transmitter Kit $299.95
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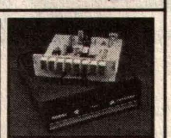
Speech Descrambler Scrambler

Decode all that gibberish! This is the popular descrambler / scrambler that you've read about in all the Scanner and Electronic magazines. The technology used is known as speech inversion which is compatible with most cordless phones and many police department systems, hook it up to scanner speaker terminals and you're in business. Easily configured for any use: mike, line level and speaker output/inputs are provided. Also communicate in total privacy over telephone or radio, full duplex operation - scramble and unscramble at the same time. Easy to build, all complex circuitry contained in new custom ASIC chip for clear, clean audio. Runs on 9 to 15VDC, RCA phono type jacks. Our matching case set adds a super nice professional look to your kit.

SS-70A, Speech Descrambler/Scrambler Kit $39.95
CSS, Custom Matching Case and Knob Set $14.95
SS-70AWT, Fully Wired SS-70A with Case $79.95
AC12-5, 12 Volt DC Wall Plug Adapter $9.95

Tone-Grabber Touch Tone Decoder / Reader



Dialed phone numbers, repeater codes, control codes, anywhere touch-tones are used, your TG-1 will decode and store any number it hears. A simple hook-up to any radio speaker or phone line is all that is required, and since the TG-1 uses a central office quality decoder and microprocessor, it will decode digits at virtually any speed! A 256 digit non-volatile memory stores numbers for 100 years - even with the power turned off, and an 8 digit LED display allows you to scroll through anywhere in memory. To make it easy to pick out numbers and codes, a dash is inserted between any group or set of numbers that were decoded more than 2 seconds apart. The TG-1 runs from any 7 to 15 volt DC power source and is both voltage regulated and crystal controlled for the ultimate in stability. For stand-alone use add our matching case set for a clean, professionally finished project. We have a TG-1 connected up here at the Ramsey factory on the FM radio. It's fun to see the phone numbers that are dialed on the morning radio show! Although the TG-1 requires less than an evening to assemble (and is fun to build, too!), we offer the TG-1 fully wired and tested in matching case for a special price.

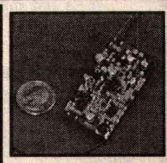
TG-1, Tone Grabber Kit $99.95
CTG, Matching Case Set for TG-1 Kit. $14.95
TG-1WT, Fully Wired Tone Grabber with Case $149.95
AC12-5, 12 Volt DC Wall Plug Adapter $9.95

Mini-Peeper Micro Video Camera

Super small, high quality fully assembled B & W CCD TV camera the size of an ice cube! Provides excellent pictures in low light (2 lux), or use our IR-1 Infra-Red light source to invisibly illuminate an entire room on a pitch black night! Imagine the possibilities... build it into a smoke detector, wall clock, lamp, book, radio. Exact same camera that's in big buck detective catalogues and stores. Kit includes: fully assembled CCD camera module, connectors, interface PC board kit with proper voltage regulation and filtering, hook-up details, even a mini microphone for sensitive sound! Two models available: Wide Angle Lens 3.6mm/f2, adjustable focus lens, 92 degree view; Pinhole Lens 5.5mm/f4.5, 60 degree view. The Pinhole Lens is physically much flatter and provides even greater depth of focus. The camera itself is 1.2" square. The Wide Angle Lens is about 1" long, Pinhole Lens about 1/2", interface PC board is 1" x 2" and uses RCA jacks for easy hook-up to VCRs, TVs or cable runs. Power required is 9 to 14 VDC @ 150 mA. Resolution: 380 x 350 lines. Instruction manual contains ideas on mounting and disguising the Mini-Peeper along with info on adding one of our TV Transmitter kits (such as the MTV-7 unit below) for wireless transmission!

MP-1, Wide Angle Lens CCD TV Camera Outfit $169.95
MP-1PH, Pin-Hole Lens CCD TV Camera Outfit $189.95

MicroStation Synthesized UHF TV Transmitter



Now you can be in the same league as James Bond. This transmitter is so small that it can fit into a pack of cigarettes - even including a CCD TV camera and battery! Model airplane enthusiasts put the MTV-7A into airplanes for a dynamite view from the cockpit, and the MTV-7A is the transmitter of choice for balloon launches. Transmitter features synthesized, crystal controlled operation for drift-free transmission of both audio and video on your choice of frequencies: Standard UHF TV Channel 52 (which should only be used outside of the USA to avoid violating FCC rules), and 439.25 MHz or 911.25 MHz which are in the amateur ham bands. The 439.25 MHz unit has the nifty advantage of being able to be received on a regular 'cable-ready' TV set tuned to Cable channel 68, or use our ATV-74 converter and receive it on regular TV channel 3. The 911.25 MHz unit is suited for applications where reception on a regular TV is not desired, an ATV-79 must be used for operation. The MTV-7A's output power is almost 100 mW, so transmitting range is pretty much 'line-of-sight' which can mean many miles! The MTV-7A accepts standard black and white or color video and has its own, on-board, sensitive electret micorphone. The MTV-7A is available in kit form or fully wired and tested. Since the latest in SMT (Surface Mount Technology) is used to provide for the smallest possible size, the kit version is recommended for experienced builders only. Runs on 12 VDC @ 150 mA and includes a regulated power source for a CCD camera.

MTV-7A, UHF TV Channel 52 Transmitter Kit $159.95
MTV-7AWT, Fully Wired Channel 52 Transmitter $249.95
MTV-7A4, 439.25 MHz TV Transmitter Kit $159.95
MTV-7A4WT, Fully Wired 439.25 MHz Transmitter $249.95
MTV-7A9, 911.25 MHz TV Transmitter Kit $179.95
MTV-7A9WT, Fully Wired 911.25 MHz Transmitter $269.95
ATV-74, 439.25 MHz Converter Kit $159.95
ATV-74WT, Fully Wired 439.25 MHz Converter $249.95
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1560 tie point breadboard area.

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XK-550K - Kit
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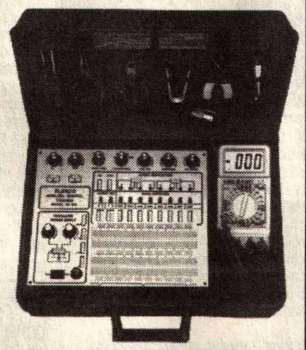
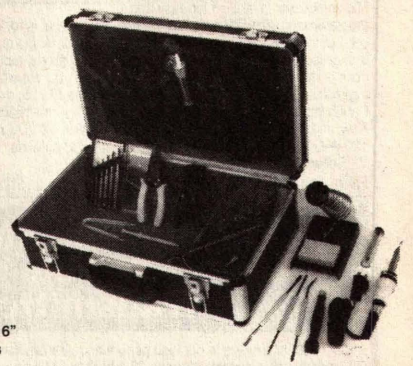
Tools and meter shown optional



TK-3000
$89.95

Tools Included:
- SR-2 - Deluxe Soldering Iron
- SH-1 - Soldering Iron Stand
- ST-1 - Diagonal Pliers
- ST-2 - Long Nose Pliers
- ST-30 - Deluxe Wire Stripper
- SE-1 - Solder Ease Kit
- ND-3 - 3 pc. Nut Driver Set
- TL-8 - Precision Screw Drivers
- ST-5 - Screw Driver Slotted 3/16"
- ST-6 - Screw Driver #1 Phillips
- ET-10 - IC Puller
- SP-2 - Solder Pump
- ST-20 - Safety Goggles
- ST-9 - Pocket Screw Driver
- ST-4 - Solder Tube
- SW-3 - Solder Wick



A professional technician service tool kit in a metal reinforced tool case with heavy-duty handle and locks. A removable pallet handles most of the tools listed with more room for tools and parts in the lower half.

GF-8026 w/ Frequency
- Linear and Log Sweep
- .02Hz to 2MHz
- Counter Range 1Hz to 10MHz
- 4 Digit Display

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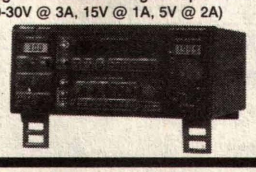
MX-9300 Four Functions in One
- One instrument with four test and measuring systems: 1.3GHz Frequency Counter • 2MHz Sweep Function Generator Digital Multimeter • Digital Triple Power Supply (0-30V @ 3A, 15V @ 1A, 5V @ 2A)



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Model XP-581
4 Fully Regulated DC Power Supplies in One Unit
4 DC voltages: 3 fixed - +5V @ 3A, +12V @ 1A, -12V @ 1A
1 Variable - 2.5 - 20V @ 2A

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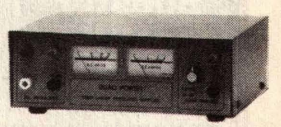

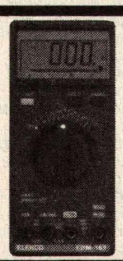

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DMM w/ Bar Graph
Model EDM-163

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7 Functions with data hold
Compares to Fluke Model 77II

Digital Multimeter
Model M-1700

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11 functions including freq to 20MHz, cap to 20µF. Meets UL-1244 safety specs.

Fluke Multimeters

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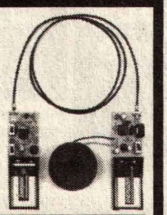
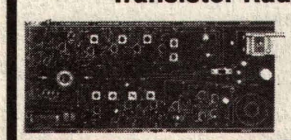


Model AM/FM-108K
Transistor Radio Kit



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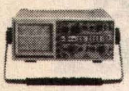

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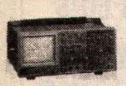
- Sweeps to 5ns/division
- Dual time base
- Signal delay line
- V mode-displays two signals unrelated in frequency.
- Component tester



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40MHz DUAL-TRACE
Model 1541C
- 1mV/division sensitivity
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- Z-axis input
- Single Sweep
- V mode displays two signals unrelated in frequency
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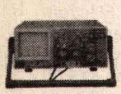
Model 2260
- Cursors and readouts
- 1mV/div sensitivity
- 23 calibrated ranges - main time base
- 19 calibrated ranges - delayed time base
- Signal delay time
- V-mode - displays 2 signals unrelated in frequency.
- Component tester
- Z-axis input
- Single sweep



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Model 2120 - 2 Year Warranty
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- AUTO/NORM triggered sweep operation
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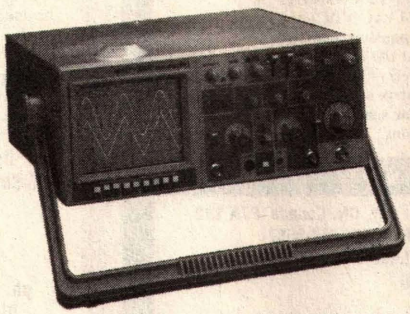

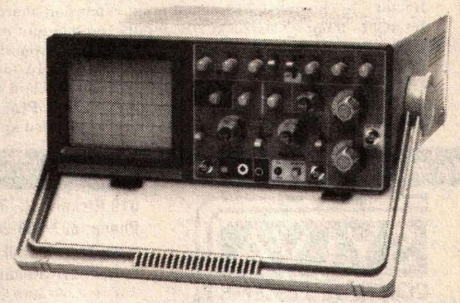

60MHz

DS-603 $1350
- Analog / Digital Storage
- 20MS/s Sampling Rate

S-1360 $749
- Analog with Delayed Sweep

40MHz

S-1345 $569
- Analog with Delayed Sweep

S-1340 $475
- Analog

25/30MHz

DS-303 $1095
- Analog / Digital Storage

S-1330 $439
- 25MHz Analog
- Delayed Sweep

S-1325 $325
- 25MHz Analog

2 Year Warranty

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ANALOG

Model	Bandwidth MHz	Sensitivity (max)	No. of Channels	Sweep Rate Max ns/div	Delayed Sweep	Video Sync	Component Tester	Beam Find	Time Base
S-1360	60	1mV/div	2	10ns/div	Yes	Yes	Yes	Yes	2
S-1345	40	1mV/div	2	10ns/div	Yes	Yes	Yes	Yes	2
S-1340	40	1mV/div	2	10ns/div	No	Yes	No	No	1
S-1330	25	1mV/div	2	10ns/div	Yes	Yes	Yes	Yes	2
S-1325	25	1mV/div	2	10ns/div	No	Yes	No	No	1

DIGITAL STORAGE

Model	Bandwidth MHz	Analog Sen (max)	No. of Channels	Sampling Rate	Memory Channel	Internally Backed Up	Pretrigger %	Output
DS-303	30	1mV/div	2	20MS/S	2K	Yes	0, 25, 50, 75	RS232
DS-603	60	1mV/div	2	20MS/S	2K	Yes	0, 25, 50, 75	RS232

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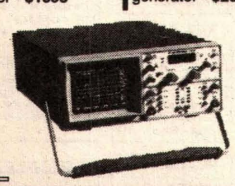
Model 2615 - $1595 Model 2620 w/ tracking generator - $1895	Model 2625 - $2395 Model 2630 w/ tracking generator - $2995



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SC552S16 - The 552S plus 8 AC/DC inputs 8 relay outputs 1 HS input 1 serial port
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AE-DAC - 8 bit 4 channel analog output exp. board (4-20mA, 0-20mA and 0-10V)
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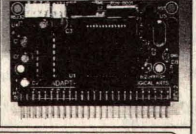

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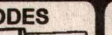

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on-off-on ...SPDT....60¢
on-on.....DPDT....70¢
on-off-on ...DPDT....80¢
Deal S3: 8 pcs total, (2pcs of each)....$5.00

Popular CMOS

CD4001B.... 30¢
CD4011B.... 30¢
CD4013B.... 40¢
CD4017B.... 50¢
CD4028B.... 40¢
CD4050B.... 40¢
CD4066B.... 40¢
CD4069B.... 40¢
Deal V8: 16 pcs total, (2pcs of each)....$5.00

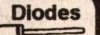
More Transistors

MPSA05.... 15¢
MPSA13.... 15¢
MPSA27.... 15¢
MPSA42.... 15¢
MPSA56.... 15¢
MPSA92.... 15¢
Deal Q2: 30 pcs total, (5 pcs of ea.).....$4.00

V. Regulators

LM317T..... 69¢
7805..... 49¢
7808..... 49¢
7812..... 49¢
7815..... 49¢
7818..... 49¢
7824..... 49¢
7905..... 49¢
7908..... 49¢
7912..... 49¢
7915..... 49¢
78L05..... 39¢
79L05..... 39¢
78L12..... 39¢

Power Diodes



1N5401 ..3A/100V . 10¢
1N5404 ..3A/400V . 11¢
1N5408 ...3A/1kV... 12¢
6A10 ..... 6A/100V.. 32¢
6A100 ..... 6A/1kV... 42¢
Deal H8: 25 pcs total, (5pcs of ea.).....$4.00

RADIAL LYTICS

10uF/25V ..... 8¢
22uF/25V ..... 8¢
33uF/25V ..... 8¢
47uF/25V ..... 9¢
100uF/25V .. 10¢
220uF/25V .. 12¢
330uF/25V .. 19¢
470uF/25V .. 23¢
Deal A7: 40 pcs total, (5pcs of each)....$4.00

Ceramic Disc
(All caps rated 50V)

270pF ..... 7¢
330pF ..... 7¢
470pF ..... 7¢
.001uF ..... 7¢
.01uF ..... 7¢
.022uF ..... 7¢
.047uF ..... 9¢
.1uF ..... 10¢
Deal R7: 40 pcs total, (5pcs of each)....$2.50

DEAL W2....$2.50

120 pcs total (20 pcs of each: 10, 47, 100, 470, 1k, 4.7k. All 1/4W 5%.

DEAL W5....$2.50

100 pcs total (20 pcs of each: 10K, 47K, 100K, 470K, 1M. All 1/4W 5%.

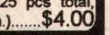
DEAL M3....$5.00

7805 7812
7905 7912
12 pcs total
(3pcs of each)

More Transistors

2N2222A... 30¢
2N4124 ..... 11¢
2N4126 ..... 11¢
2N5401 ..... 14¢
MPSH10 ... 13¢
2N3055 ..... 69¢
TIP31C ..... 55¢
TIP32C ..... 55¢
TIP117 ..... 55¢
TIP120 ..... 60¢
TIP125 ..... 65¢

1W Zener Diodes



1N4728A.... 3.3V ... 10¢
1N4733A.... 5.1V ... 10¢
1N4739A.... 9.1V ... 10¢
1N4742A..... 12V .... 10¢
1N4744A..... 15V .... 10¢
1N4746A..... 18V .... 10¢
Deal Z5: 30 pcs total, (5pcs of ea.).....$3.00

1A SCHOTTKY

1N5817 ...1A/20V .. 22¢
1N5818 ...1A/30V .. 23¢
1N5819 ...1A/40V .. 24¢
Deal Y6: 9 pcs total, (3pcs of each)....$2.00

Mono Caps....9¢ea

.01uF/50V .047uF/50V
.022uF/50V .1uF/50V
Deal B5: 40 pcs total, (10pcs of ea.).....$2.50

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1Amp 4Amp 1.5Amp

DF04M.....DIP ..... 40¢
W04M..... Round ... 35¢
KBL04.....In-line ... 89¢
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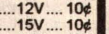
DEAL J1.....$3.50

78L05
78L12
10 pcs total
(5pcs of each)

Crystals.....99¢ea

3.5795MHz, 4.000MHz
11.0MHz, 11.0592MHz

Germanium Diodes



1N34A..... 15¢
1N60..... 15¢
1N270..... 30¢
Deal G5: 18 pcs total, (6pcs of each).....$2.50

3A SCHOTTKY

1N5820 ...3A/20V .. 32¢
1N5821 ...3A/30V .. 36¢
1N5822 ...3A/40V .. 39¢
Deal Y9: 9 pcs total, (3pcs of each)....$3.00

Tantalum Caps

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2.2uF/35V ... 22¢
10uF/35V .... 49¢
Deal T6: 15 pcs total, (5pcs of each)....$3.50

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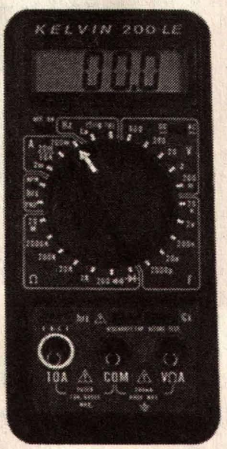

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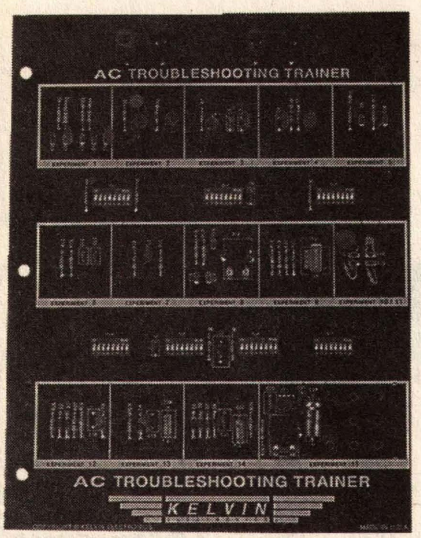

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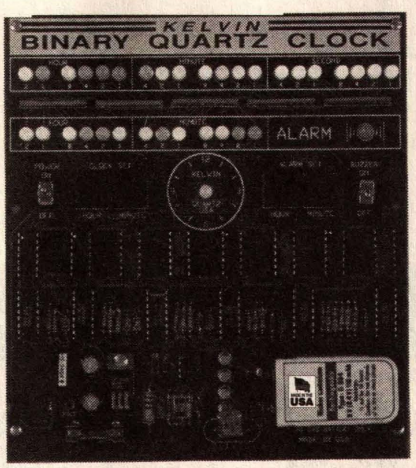

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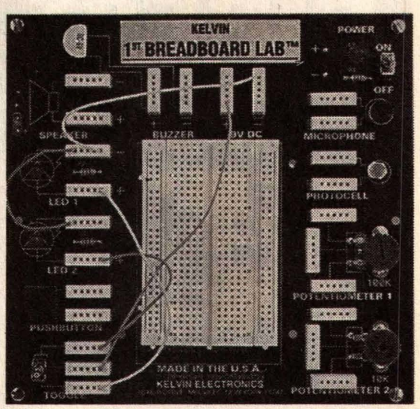

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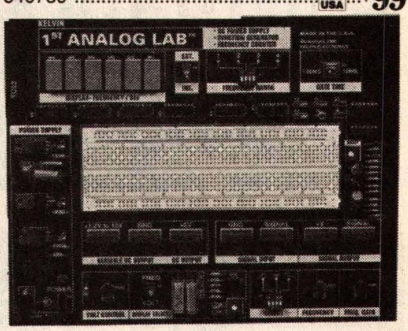

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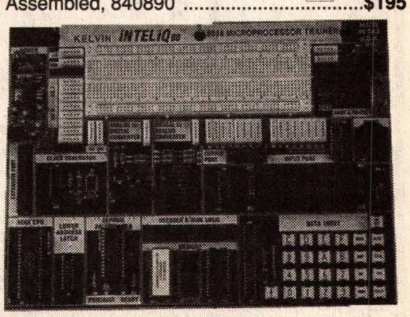

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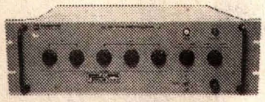

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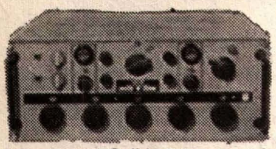

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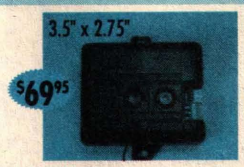

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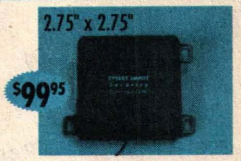

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- All Channels are Programmable for Momentary, Latched, Latched with Condition 30-60-90 Sec. Timed Outputs
- Code Hopping Receiver at 434 Hhz
- Compatible with 2 Button or 4 Button Remote
- Compatible with Some Car Alarms

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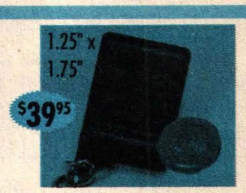
- Extra Long Range 434 Mhz with S.A.W. Resonator
- Push Both Buttons together for Channel 3



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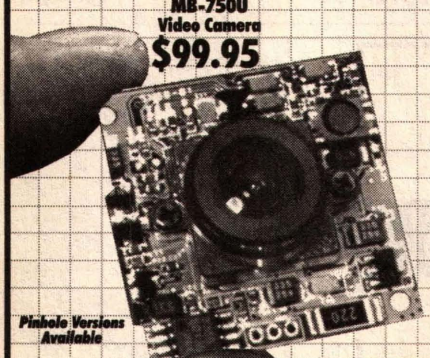

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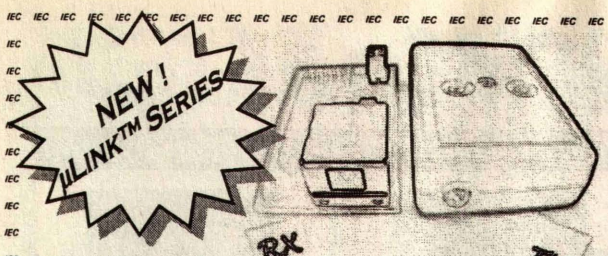

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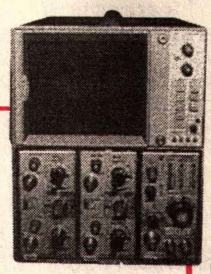

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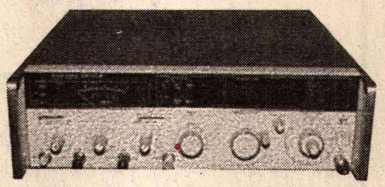
2 new probes and operators manual

HEWLETT PACKARD 8640B



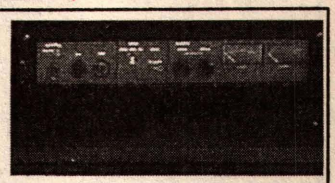
The 8640B is a 0.5 to 512Mhz Signal Generator with optional coverage to 1024 Mhz. This generator is also a 550Mhz counter.
The 8640B Features: **$1,295**

- low SSB phase noise
- +19 to -145 dBm output power range
- Calibrated, metered AM, FM, and Phase Modulation
- Internal Phase lock/synchronizer, digital frequency

Option 001 20hz to 600Khz internal audio oscillator ADD $150
Option 003 50Watt reverse power protection ADD $150

HEWLETT PACKARD 8640B 0.5 TO 1024MHZ **$1,995**

HIGH POWER BURN-IN SUPPLY
SORENSEN DCR 4-800T

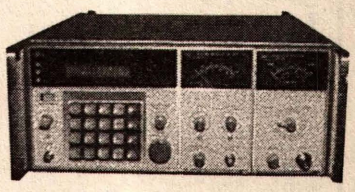


This 5KW high power programable supply
is designed to meet requirements for the burn-in market.
4 Volt 800Amp. **$695**

HP 8660C Mainframe
Programmable Signal Generator

- 1Hz Resolution
- Ten digit display
- Sweeps

$995
(plug-ins sold seperately)



HP 11661B $595
(option 100) Extends frequency

Sorensen DCR 20-25B-2 20volts 25 amps **$495**

HP 5340A Frequency counter 10Hz to 18Ghz **$1,595**

HP 8601A AM/FM signal generator .5 to 512Mhz **$495**

Racal Dana 9082P synthesized signal generator
1.5 to 520Mhz **$1,095**

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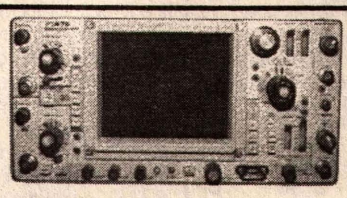
Plug-in	Specifications	Price
86601A	RF section 10Khz to 110Mhz -146 to +13dBm output	$495
86602B	RF section 1 to 1300Mhz -146 to +10dBm output	$795
86603A	RF section 1 to 2600Mhz -136 to +13dBm output	$1,995
86632B	AM and FM modulation	$595
86635A	Phase and FM modulation	$795

Tektronix 465
100Mhz at 5mV/div
2 Channel
2nS/div Sweep Rate
X10 Sweep Magnification
$595



Tektronix 475
200Mhz at 5mV/div
2 Channel
1nS/div Sweep Rate
X10 Sweep Magnification
Trigger View
$750

These scopes weigh 23lbs, Width 13.1 inches, Height 6.3 inches, Depth 18.1 inches

Included Accessories: 2 new probes, operators manual, pouch, and cover.

Tech-Systems Electronics, Inc.

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Fantastic DMM Offer!!!

Don't let the price fool you. This meter is a digital multimeter designed for engineers and hobbyists. Equipped with 5 functions and 19 ranges. Each test position is quickly and easily selected with a simple turn of the FUNCTION/RANGE selector rotary switch. ***Rubber Boot Included***

Our Best Offer Ever on a High Quality Full Sized DMM

General

Display: 3-1/2 Digit LCD, 21mm Figure Height with Automatic Polarity
Overrange Indication: 3 Least Significant Digits Blank
Temperature for Guaranteed Accuracy: 23°C±5°C RH<75%
Temperature Ranges:
Operating: 0°C to 40°C (32°F to 104°F)
Storage: -10°C to 50°C (14°F to 122°F)
Power: 9V Alkaline or Carbon-Zinc Battery(NEDA 1604)
Low Battery Indication: BAT on Left of LCD Display
Dimensions: 188mm long x 87mm wide x 33mm thick
Net Weight: 400g

DC Voltage (DCV)

Range:	*Resolution:*	*Accuracy:*
200mV	100µV	
2000mV	1mV	
20V	10mV	±(1%rdg+2dgts)
200V	100mV	
1000V	1V	

Maximum Allowable Input: 1000V DC or Peak AC.

DC Current (DCA)

Range:	*Resolution:*	*Accuracy:*
200µA	100nA	
2000µA	1µA	
20mA	10µA	±(1.2%rdg+2dgts)
200mA	100µA	
10A	10mA	±(1.2%rdg+2dgts)

Overload Protection: mA Input. 2A/250V fuse.

AC Voltage (ACV)

Range:	*Resolution:*	*Accuracy:*
200V	100mV	±(1.2%rdg+10dgts)
750V	1V	

Frequency Range: 45Hz-450Hz
Maximum Allowable Input: 750V rms
Response: Average Responding. Calibrated in rms of a Sine Wave.

$19.00 any qty

Resistance (Ω)

Range:	*Resolution:*	*Accuracy:*
200Ω	100mΩ	
2000Ω	1Ω	
20KΩ	10Ω	±(1.2%rdg+2dgts)
200KΩ	100Ω	
2000KΩ	1KΩ	
20MΩ	10KΩ	±(2%rdg+10dgts)

Maximum Open Circuit Voltage: 2.8V

Diode Test
Measures forward voltage drop of a semiconductor junction in mV test current of 1.5mA Max.

ohFE Test
Measures transistor hFE.

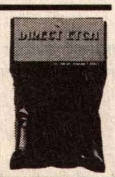
CAT NO	DESCRIPTION	PRICE
9300G	Rugged High Quality DMM with Rubber Boot	$19.00

Switchable Scope Probe Sets

(Selectable X1/Ref/X10) These high quality scope probe sets are for oscilloscopes up to 60MHz (model HP 9060) or 150MHz (model HP9150). Both sets include a handy storage pouch and include an IC test-hook adapter for the probe. The BNC connector rotates to avoid cable tangle or kink. Cable length is 1.4 meters.

CAT NO	DESCRIPTION	PRICE EACH 1	10	100
HP-9060	Scope Probe Set DC~60MHz	$16.49	$14.49	$11.58
HP-9150	Scope Probe SetDC~150MHz	24.95	21.95	18.62

Etching Chemicals/Ferric Chloride



A dry concentrate that mixes with water to make 1 pint of etchant, enough to etch 400 sq. inches of 1oz board.

CAT NO	DESCRIPTION	PRICE EACH 1	5
ER-3	Makes 1 pint	$3.50	$2.75

Positive Photo Resist Pre-Sensitized Printed Circuit Boards

These pre-sensitized printed circuit boards are ideal for small production runs. They provide high resolution and excellent line width control. High sensitive positive resist coated on 1oz. copper foil allows you to go direct from your computer plot or art work layout. No need to reverse art.

Single-Sided, 1oz. Copper Foil on Paper Phenolic Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
PP101	100mm x 150mm/3.91" x 5.91"	$2.55	$1.90	$1.70
PP114	114mm x 165mm/4.6" x 6.6"	2.98	2.45	1.98
PP152	150mm x 250mm/5.91" x 9.84"	5.40	3.98	3.60
PP153	150mm x 300mm/5.91" x 11.81"	6.15	4.48	4.10
PP1212	305mm x 305mm/12" x 12" *NEW!*	12.78	10.65	8.52

Single-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GS101	100mm x 150mm/3.91" x 5.91"	$ 3.90	$2.98	$2.60
GS114	114mm x 165mm/4.6" x 6.6"	4.80	3.49	3.20
GS152	150mm x 250mm/5.91" x 9.84"	8.69	5.98	5.78
GS153	150mm x 300mm/5.91" x 11.81"	10.20	7.20	6.80
GS1212	305mm x 305mm/12" x 12" *NEW!*	18.88	15.73	12.59

Double-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GD101	100mm x 150mm/3.91" x 5.91"	$ 5.07	$3.68	$3.38
GD114	114mm x 165mm/4.6" x 6.6"	5.95	4.29	3.99
GD152	150mm x 250mm/5.91" x 9.84"	10.47	7.39	6.98
GD153	150mm x 300mm/5.91" x 11.81"	11.95	8.69	8.30
GD1212	305mm x 305mm/12" x 12" *NEW!*	22.09	18.35	14.68

Developer

This product is used as the developer on our positive photo-resist printed circuit boards. Includes instructions. 50 gram package, mixes with water, makes 1 quart.

CAT NO	DESCRIPTION	PRICE EACH 1	10	25
POSDEV	Positive Developer	$ .95	$ .80	$ .50

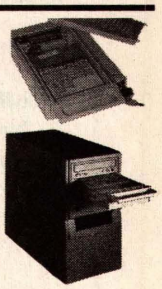
Etching Tank

This handy etching system will handle PC boards up to 8" x 9", two at a time. Ideal for etching your PCB's! System includes an air pump for etchant agitation, a thermostatically controlled heater for keeping etchant at optimum temperature and a tank that holds 1.35 gallons of etchant. A tight fitting lid is also supplied to prevent evaporation when system is not being used. Typical etching time is reduced to 4 minutes on 1oz. copper board!

REDUCES ETCHING TIME!

CAT NO	DESCRIPTION	PRICE
12-700	Etch Tank System	$37.95

Removeable Hard Drive Racks



The ideal solution for protecting highly sensitive data. Or, buy one computer and allow individual users to keep their hard drive with their own applications and set-ups. Just turn the system off, lift the handle and the hard drive pops right out. Key lock included to avoid accidental or unauthorized removal. Includes hard drive activity LED's. Rack includes mounting hardware, keylock, front panel LED, convenient pull out handle. Made from high impact ABS plastic. Fits in 5.25" bay.

Features: • Ideal for Hard Drive Portability • Solve Software Data Security Issues • Carry Your Hard Drive Between Home and Office • Each User Can Have His or Her Personal Hard Drive

CAT NO	DESCRIPTION	PRICE
SpecialHDRACK-IDE	For IDE Hard Drive	$14.95

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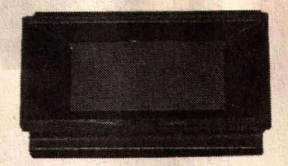
Digital Panel Meters (LCD & LED)

Don't let the prices fool you. These digital panel meters are not surplus, so even if you design them into an ongoing manufactured product, you can be assured of continued availability. These high quality digital panel meters are decimal point selectable with guaranteed zero reading at zero volts input.



Applications Include:

- Voltmeter
- Thermometer
- pH Meter
- dB Meter
- Watt Meter
- Current Meter
- Capacitance Meter
- LUX Meter
- LCR Meter
- Other Industrial & Domestic Uses

PM-128: 3-1/2D LCD Digital Panel Meter

PM-129: 3-1/2D LED Digital Panel Meter

Features

- 200mV Full Scale Input Sensitivity
- PM-128 - Single 9VDC Operation
- PM-129 - Single 9VDC Operation
- Decimal Point Selectable
- PM-128 - 13mm Figure Height
- Automatic Polarity Indication
- Guaranteed Zero Reading for 0 Volt Input
- High Input Impedance (>100Mohm)

Specifications - PM-128/PM-129

Maximum Input	: 199.9mV DC
Maximum Display	: 1999 counts (3-1/2 Digits) w/Automatic Polarity Indication
Indication Method	: PM-128 - LCD Display PM-129 - LED Display
Measuring Method	: Dual-Slope Integration A/D Converter System
Overrange Indication	: "1" Shown in the Display
Reading Rate Time	: 2-3 Readings per sec.
Input Impedance	: >100 Mohm
Accuracy	: +-0.5% (23+-5°C, <80% RH)
Power Dissipation	: PM-128 - 1mA DC PM-129 - 60mA DC
Decimal Point	: Selectable w/Wire Jumper
Supply Voltage	: PM-128 - 9V DC PM-129 - 9V DC
Size	: 67mm x 44mm

3-1/2 Digit LCD 3-1/2 Digit LED 4-1/2 Digit LCD

PM-328: 4-1/2D LCD Digital Panel Meter

Features

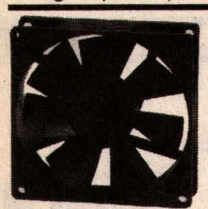
- 200.00mV Full Scale Input Sensitivity
- Single 9V DC Operation
- Decimal Point Selectable
- 11mm LCD Figure Height
- Automatic Polarity Indication
- Low Battery Detection and Indication
- High Input Impedance (>100 Mohm)

Specifications - PM-328

Maximum Input	: 199.99mV DC
Maximum Display	: 19999 counts (4-1/2 Digits) w/Automatic Polarity Indication
Indication Method	: LCD Display
Overrange Indication	: "1" Shown in the Display
Input Impedance	: >100 Mohm
Accuracy	: +-0.05% (23+-5°C, <80% RH)
Power Dissipation	: 1mA DC
Decimal Point	: Selectable w/Wire Jumper
Supply Voltage	: 9V DC
Size	: 67mm x 44mm

AS LOW AS $5.25 ea.

CAT NO	DESCRIPTION	PRICE EACH 1	10	25	100	250
PM-128	3-1/2 Digit LCD Panel Meter	$ 9.90	$ 7.09	$ 6.40	$ 5.86	$ 5.25
PM-129	3-1/2 Digit LED Panel Meter	11.49	9.54	8.67	7.95	6.95
PM-328	4-1/2 Digit LCD Panel Meter	19.88	16.40	14.90	13.66	11.93



Ball Bearing 12V DC Fans

These High Quality Fans feature Ball Bearings and Brushless DC Motors. All of them are designed to meet UL, CSA & VDE Standards. Design these fans into power supplies, computers or other equipment requiring additional air flows for heat removal. These fans are regular Circuit Specialists stock items — they are not surplus.

INDUSTRY BEST PRICING!

CAT NO	PRICE EACH 1	10	25	100
CSD 4010-12	$ 9.88	$ 6.38	$5.48	$4.87
CSD 6025-12	9.38	5.91	5.41	4.71
CSD 8025-12	8.88	5.85	5.19	4.49
CSD 9225-12	8.95	6.14	5.29	4.59
CSD 1225-12	11.45	8.96	7.82	6.85

Specifications

CAT NO	DIMENSIONS (MM)	RATED VOLTAGE (V)	START VOLTAGE (V)	INPUT CURRENT (A)	AIR FLOW (CFM)	STATIC PRESSURE ($INCH-H_2O$)	SPEED (RPM)	NOISE LEVEL (dB)	WEIGHT (g)
CSD 4010-12	40x40x10mm	12	7	0.06	5.1	0.19	5,500	26	20
CSD 6025-12	60x60x25mm	12	5	0.13	13.7	0.165	4,500	28	65
CSD 8025-12	80x80x25mm	12	5	0.16	37.8	0.177	3,000	31	80
CSD 9225-12	92x92x25mm	12	5	0.32	42	0.18	2,800	37	95
CSD 1225-12	120x120x25mm	12	5	0.35	62	0.180	2,500	42	135

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We stock high quality 60/40(Sn%/Pb%), .031" and 63/37, .031" diameter. This is prime JIS certified solder that we maintain as a regular stock item (It is not "Left-overs, Rejects or Surplus") and you can buy it from us at a fraction of the price that you are used to.

Tired of Paying Inflated Prices for Solder?

CAT NO	DESCRIPTION	PRICE EACH 1	10	25
RH60-1	1-lb. Spool, .031", 60/40	$ 6.90	$ 5.96	$ 5.30
RH63-1	1-lb. Spool, .031", 63/37	6.95	6.10	5.41
RH60-4	4.4-lb. Spool, .031", 60/40	24.00	21.90	17.92
RH60-TUBE	6-oz. Tube, .031", 60/40	.99	.89	.79

CCD Camera - IR Responsive

As Low As $85!!

This black and white monochrome CCD Camera is totally contained on a PCB (70mm x 46mm). The lens is the tallest component on the board (27mm high from the back of the PCB) and it works with light as low as 0.1 lux. It is IR Responsive for use in total darkness. It comes with six IR LED's on board. It connects to any standard monitor, AUX or video input on a VCR or through a video modulator to a TV. Works with a REGULATED 12V power supply (11V-13V). Hooks up by connectiong three wires: red to 12V, black to ground (power & video) and brown to video signal output.

Power Supply Regulating Kit for CA-H34 This simple kit is designed to fit onto the back of the CA-H34 CCD camera. It resolves the problem of hooking up the camera to an UNREGULATED supply (which damages the camera) by providing safe regulated power from any 12V-14V DC supply. It also provides regulated 12V DC from a 12V AC source.

CAT NO	DESCRIPTION	PRICE EACH 1	5
CA-H34A	PCB Mounted IRCCD Camera	$99.00	$85.00
A34	Power Supply Regulating Kit	$6.95	-----

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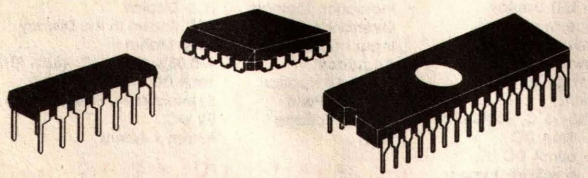

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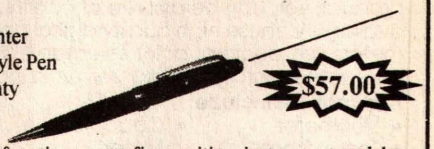

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This laser pointer functions as a fine writing instrument and laser pointer all in one. The push-button activated 650nm laser in this pointer appeares four times brighter than standard laser pointers. Output power: 3.5 to 4.5 milliwatts. Includes batteries and gift box.

Cat. #: LPPEN EXCEPTIONAL PRICE!!! $57.00

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- Broad support for additional devices using adapters.

Adapters Available

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EP-11 (68HC11 E/A)	$59.95
EP-PIC (16C5x,61,62x,71,84)	$49.95
EP-PIC64 (16C62,63,64,65,73,74)	$39.95
EP-PEEL (ICT 22V10, 20G10, 18V8)	$59.95
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EP-Z8 (Z86E03,04,05,06,07)	$39.95
EP-55 (8755)	$39.95
EP-51-PLCC (8751,C51)	$59.95
EP-PIC-SOIC(16C5x,61,62x,71,84)	$59.95
EP-PLCC (PLCC EPROMs)	$49.95
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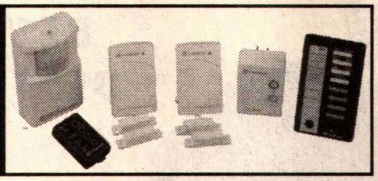

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The Weller WLC100 solder station is ideal for the professional, serious hobbyist, or kit builder who demands higher performance than usual of a standard iron, but without the high cost of an industrial unit. Power is adjustable from 5 to 40 watts. Includes 40 watt pencil iron. UL approved. Net weight: 1-3/4 lbs.

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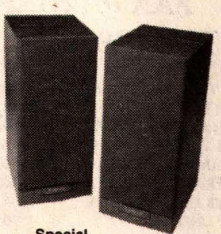

These are the best sounding little speakers you can find at anywhere near this price! Perfect for rear channel use in a home theatre system or for outdoor use. Features 4" polypropylene woofer, 2" polycone midrange, 3/4" dome tweeter housed in a weatherized polystyrene enclosure. Frequency response: 90-20,000 Hz. Impedance: 4 ohms. Power handling: 30 watts RMS/60 watts max. Mounting brackets included. 7-1/4" H x 4-5/8" W x 4-3/8" D. Net weight: 6 lbs.

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- Frequency response: 20-18KHz.

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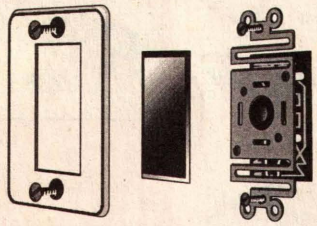

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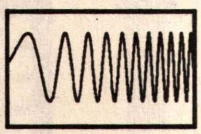
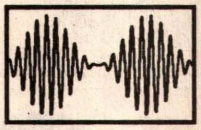
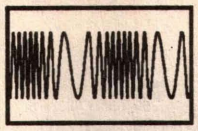


DC to 20 MHz linear and log sweeps



Int/Ext AM, SSB, Dualtone Gen.



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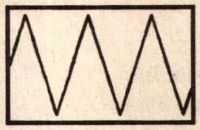
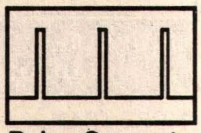
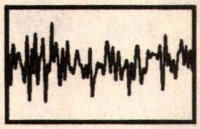


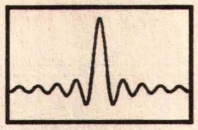
Ramps, Triangles, Exponentials



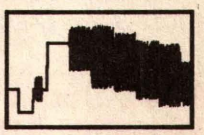
Pulse Generator



Noise



Arbitrary Waveforms



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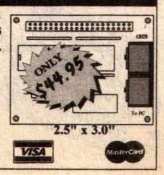

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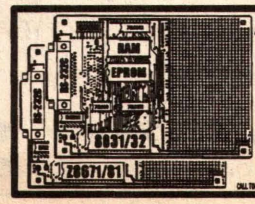

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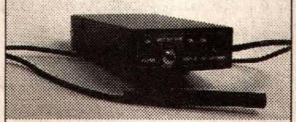

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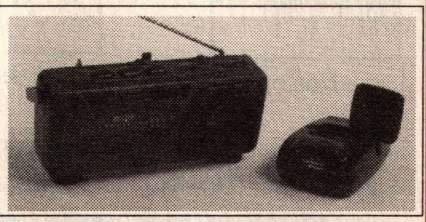

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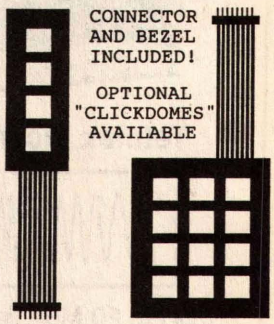

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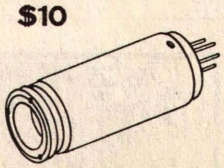

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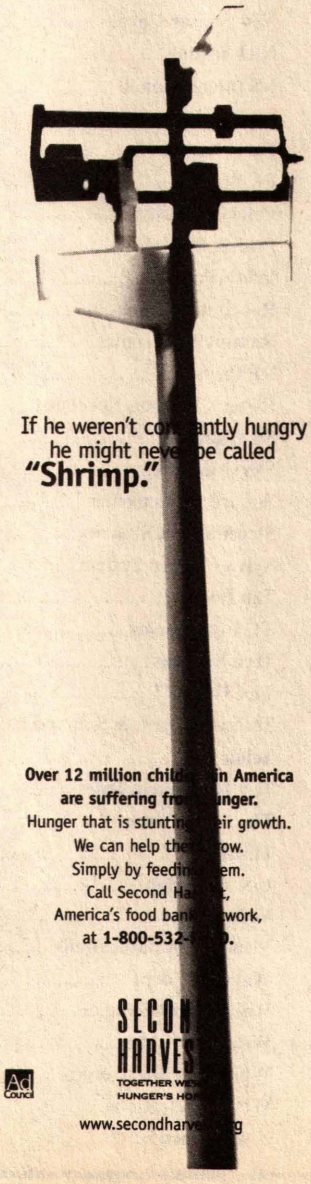

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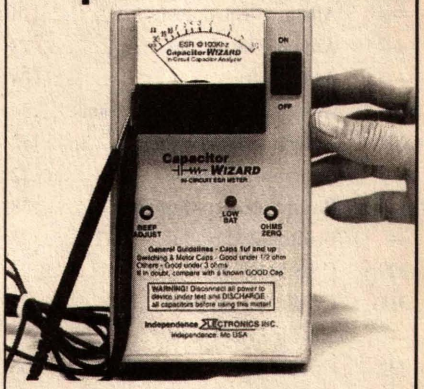

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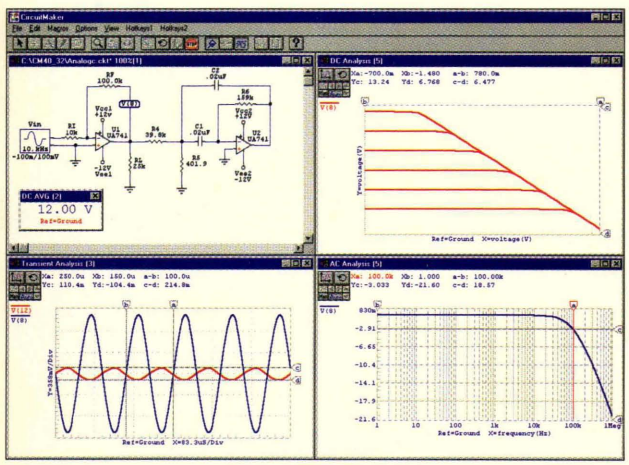

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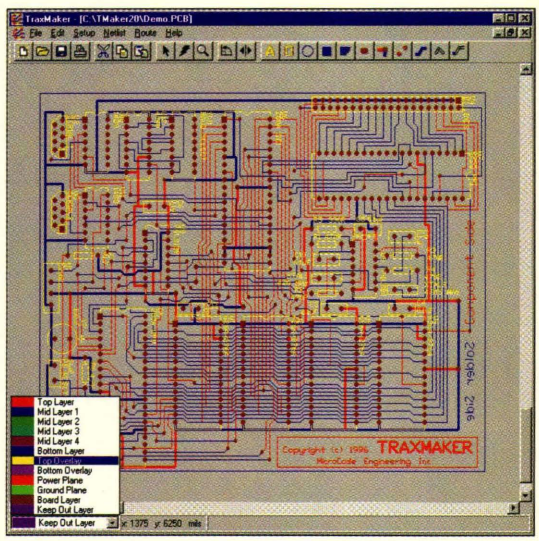

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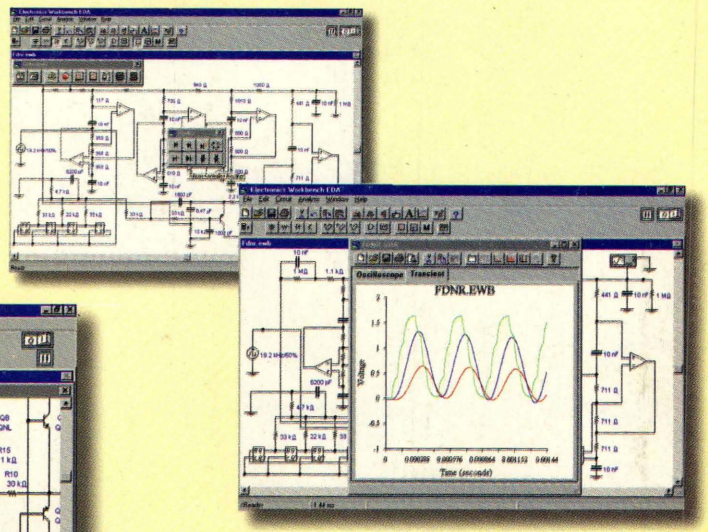

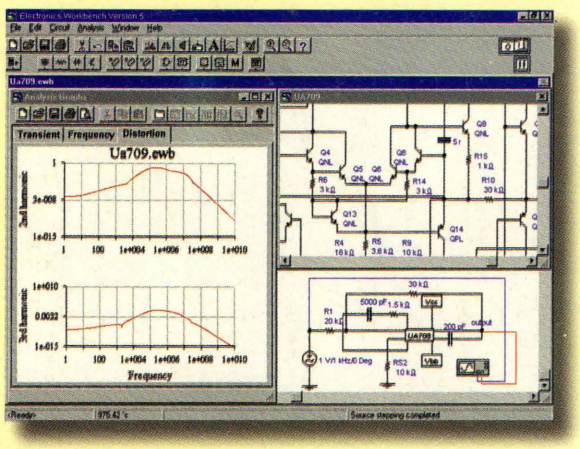

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